POWER PLANT ENGINEERING

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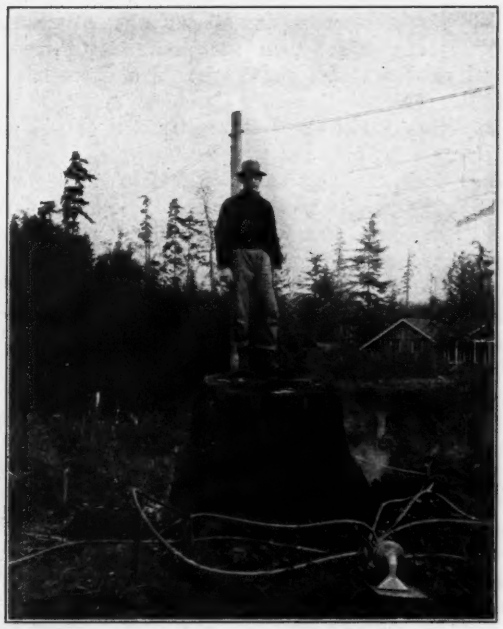


Stumps Vacuum Cleaned

THE OLD WAY: Dynamite—a fuse and—Whoosh goes the stump—all over the lot. Then you go collect it, spend hours burning it and have the roots yet to dig.

The new way: Comes the vicious, mild appearing little household vacuum cleaner and sets up its familiar growl. Presently, the stump just vanishes into thin air, —roots and all. It's all over and all done. There is no more. Just the difference between uncontrolled, destructive energy and power efficiently directed.

Air blasts from the cleaner, which in this case is really a blower, just force the flames into all parts of the stump and up it goes in smoke.

Vacuum cleaning for houses, buildings, even power plants, has long been established. Now the pioneer has taken it into the wide open spaces and gone after the stump lot. David and Goliath.

That use of electricity in a combustion system, however, is only one known to engineers, for in the power plant a veritable robot operated by electricity does the heavy, dirty, dusty work of handling coal. The anatomy of these robots is extremely interesting but it is the nerve system that fascinates and holds the attention of those who watch their operations. With uncanny precision, these electrical coal passers not only do their work but sense danger. How is this done? The answer is too long for this column but your curiosity can be satisfied by turning to page 488 and reading Mr. Raube's article on driving coal handling systems.

Power for the Dow Chemical Co.

UNUSUAL ARRANGEMENT OF TURBINES AND BOILERS SUPPLIES STEAM AND POWER TO A GREAT CHEMICAL INDUSTRY

POWER GENERATION and utilization problems in a large chemical industry are always complicated by the necessity for continuous operation and for almost constant expansion and changes in the processes to meet increased demands and to develop new materials and methods. The plant of Dow Chemical Co. at Midland, Mich., forms one of the best illustrations of this situation that can be found at the present time.

Dow Chemical Co. operates a great chemical factory at Midland, Mich., where exist vast deposits of natural brine that contains materials which it recovers and manufacturers into divers combinations for the chemical industry. The brine is pumped from the ground and contains principally sodium, magnesium and calcium compounds, as well as bromine. The numerous processes enables practically all of the products from brine to be utilized to the greatest extent. For example, one of the interesting chemical compounds in the brine is magnesium chloride from which Dow Metal is manufactured. This metal is principally metallic magnesium which is extremely light and strong and has found application in making internal combustion engine pistons.

The process departments of this great industry cover an area of about 250 acres, employing approximately 2500 workers and manufacturing approximately 200 different products.

General Power and Steam Conditions

Large amounts of steam and electric power are needed for these processes. In addition the industry uses about 130,000,000 gallons of water per day for various purposes, all of which is pumped by steam and electric driven water pumps. Electric power is generated by steam turbines and engines, all arranged so that the maximum amount of power is generated from the throttle steam before the exhaust steam from these units is used in process work. Practically all of the steam used in the plant is generated at 385 lbs. pressure, with suitable superheat to utilize this steam most efficiently through power units and the steam is exhausted from the power units at various pressures required by process conditions.

Several steam piping systems are used, operating at 385 lb., 150 lb., and 8 lb., and 26 in. of mercury and there are several electric transmission systems. Much of the current is utilized as direct current required for process purposes requiring in many cases conversion from alternating current.

The power plant to be described here, known in the Dow Chemical Co. as the N-T plant has a generating capacity of about 15,000 kw. Engine-driven generators and turbine-driven generators in other buildings raise

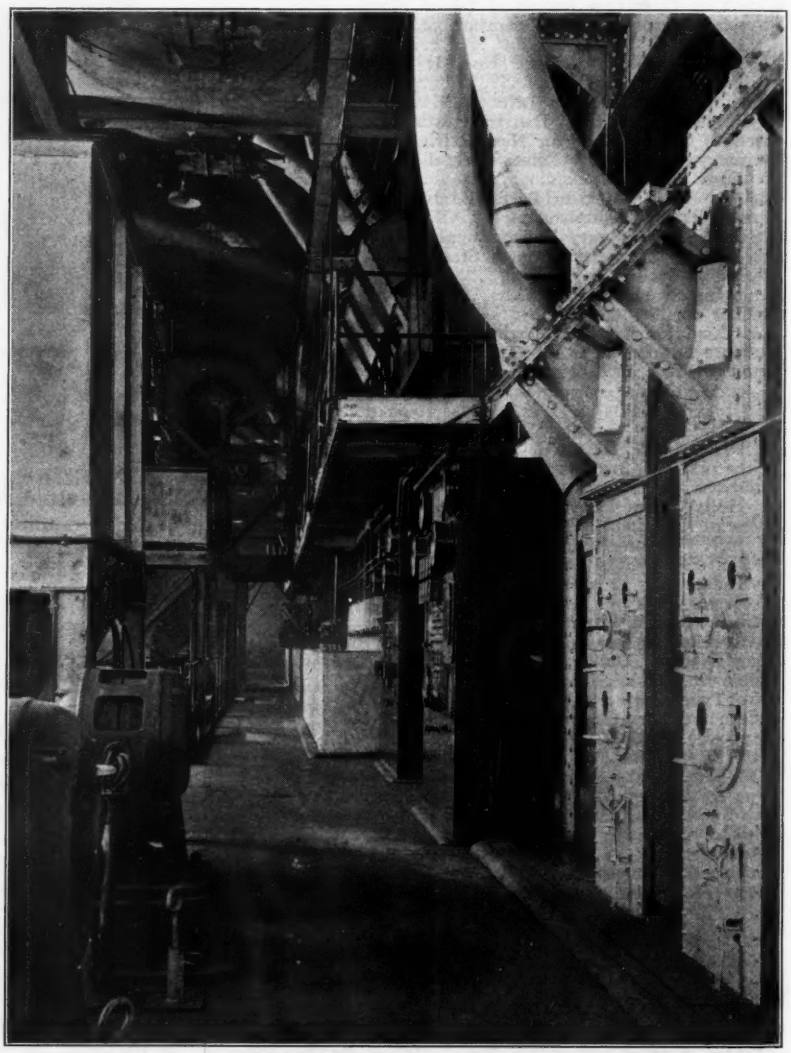


FIG. 1. LOOKING DOWN THE FIRING AISLE FROM BOILER NO. 6. AT THE LEFT ARE THE COAL HOPPERS OF THE UNIT PULVERIZERS, FED BY THE LARRY

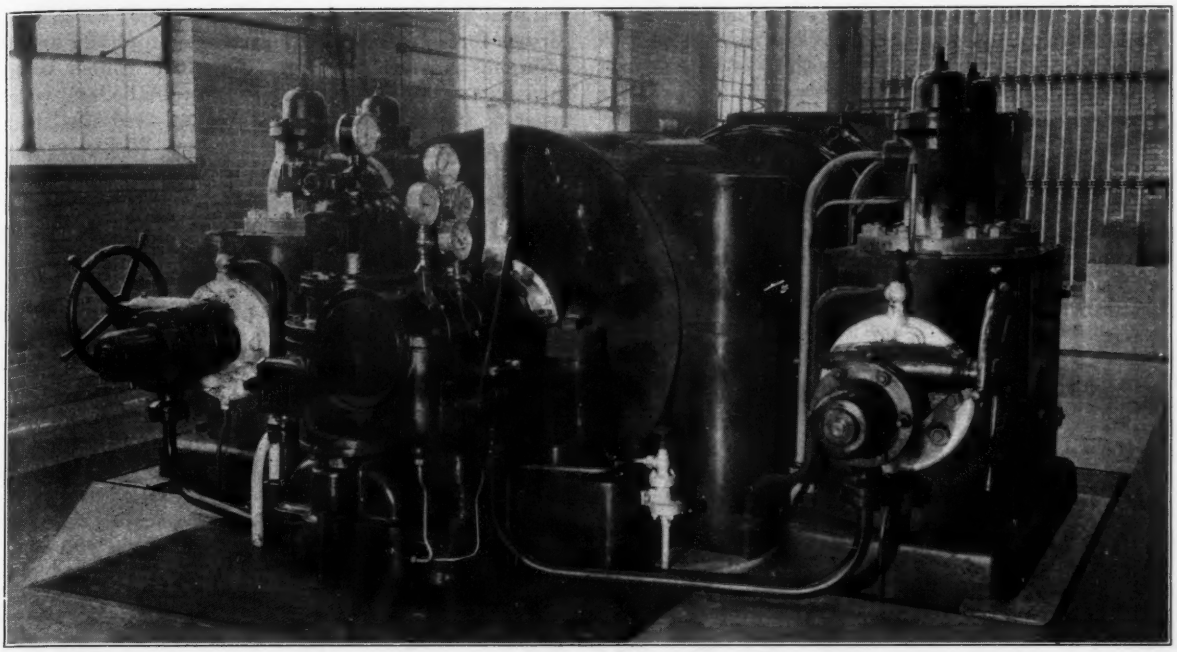


FIG. 2. ONE OF THE BROWN-BOVERI 5000-KW. TURBINE-GENERATORS TAKING STEAM AT 350 LB. AND EXHAUSTING TO THE 150-LB. STEAM SYSTEM

the total generating capacity to about 38,000 kw. In the present plant that is shown in the accompanying illustrations, practically all the steam is made for the industry at 385 lb., the turbines with one exception being back-pressure units and exhausting at 150 lb. gage. This arrangement permits existing old 150-lb. boiler plants to be shut down most of the time and to be used only when needed to augment the 150-lb. steam supply.

Triple-Expansion Turbine

In the N-T plant, Fig. 5, is installed one of the most interesting turbine generator sets that has ever been built. This is a De Laval triple expansion unit, with the high, intermediate and low-pressure rotors all revolving at different speeds. The high-pressure rotor with a speed of 10,000 r.p.m. takes steam at the throttle at 350 lb. gage pressure, 600 deg. total temperature, exhausting at 150 lb. to the intermediate rotor which has a speed of 4120 r.p.m. After passing through the intermediate cylinder, the steam at atmospheric pressure goes to the low-pressure rotor, which revolves at 3280 r.p.m. and passes out at 26 in. vacuum to process evaporators. These are equipped with Ingersoll-Rand Co. barometric condensers with steam jet and reciprocating air removal equipment. Figure 6 shows the arrangement of the turbine cylinders and the way the rotors are connected by pinions to the DeLaval double helical gear, through which they drive three generators coupled in line. The arrangement of turbine cylinders permits the unit to be operated in case of emergency under various steam inlet and exhaust conditions.

Figure 5 shows the complete unit. The turbine, through the double helical gear, drives three generators at 720 r.p.m. coupled in line. Two of these are G.E. 1500-kw., 300-v., d.c. machines and the third is a G.E. 1000-kw., 2300-v., 3-phase, 60-cycle a.c. unit.

When this unit was installed about four years ago, it was designed to be as efficient a machine as could be built of its size. It has an extremely flat water rate curve. An enclosure has been built over the generators to permit them to be operated on an enclosed water-cooled air system.

Back-Pressure Turbine-Generators

Two Brown-Boveri 5000-kw. back pressure turbines are also found in the N-T power house. These are rated at 5000-kw. at 0.8 p.f. and 6250 kw. at 1.0 p.f. They operate at 3600 r.p.m. take throttle steam at 350 lb., 600-deg. and exhaust to the 150-lb. steam system. They drive 2300-v., 3-phase, 60-cycle Brown-Boveri generators, ventilated by closed systems using Griscom-Russell air coolers as shown in Fig. 3.

Another Brown-Boveri turbine generator unit, installed in a separate building takes steam from the 150-lb. steam system and exhausts to the 8-lb. steam system. This turbine drives a 5000-kw., 2300-v., 3-phase, 60-cycle generator at 3600 r.p.m.

One of the high-pressure machines, Fig. 2, together with the low-pressure unit noted above, supply alternating current to one 2300-v. electric transmission system throughout the mill, while the other high-pressure turbine generator supplies another system. The 150-lb. steam system is the general system that runs throughout the mill. From it a great deal of the process equipment takes steam, as well as some of the older generating equipment, such as the engine-driven .d.c. generators and the water pumping equipment.

The 8-lb. steam system also takes exhaust from engine-generator units and pumping equipment and supplies steam to low-pressure process equipment.

Thus it can be seen that the generating units are in reality reducing valves between the various steam systems. Even in the case of the triple expansion unit, the 26-in. vacuum at which it exhausts is obtained not in a

regular condenser but in a commercial brine evaporator. The generating equipment is thus kept as free as possible from complication and the heat of all exhaust steam is utilized in some way, thus permitting power to be made at low cost.

Steam Generating Equipment

Steam for the above generating equipment and process steam systems is generated by six boilers, Fig. 1. These operate at 385 lb. gage pressure with superheaters designed to give about 600 deg. total steam temperature. A Leeds & Northrup combustion control system is installed on boilers 3, 4 and 5. Each boiler has a continuous blowdown system, the heat exchangers being located in a bank at the center of the boiler room. To insure continuity of steam supply to the 150-lb. system in case of turbine shut-down or breakage to the 150-lb. system, a Schutte & Koerting desuperheater reducing station is installed.

Boilers 1 and 2 are 8190 sq. ft. Wickes cross-drum water tube boilers fired by Taylor 7-retort underfeed stokers. These stokers, of the clinker-crusher type are driven by two variable-speed, direct-current motors. Furnaces of these two units each have a volume of 2800 cu. ft. Foster Wheeler convection type superheaters are installed and air is preheated by Dow air preheaters designed to give air temperature of about 350 deg. F. Sirocco forced and induced draft fans supply air and in addition, the flue gas from these two boilers passes through two Wickes vertical water tube boilers, which generate steam at 10 lb. pressure and feed this steam into the 8-lb. steam system. The two Wickes vertical boilers are placed between main boiler and air heater and serve as economizers to temper the preheated air so it can be used under the stokers.

Four Boilers Fired by Pulverized Coal

Boiler No. 3 is a 15,011-sq. ft. Wickes cross drum unit fired by pulverized coal. Two Aero 4-t. pulverizing mills, each driven by a G.E. 2300-v. squirrel cage motor supply coal to this furnace. Foster Wheeler straight-shot burners are used, secondary air being supplied around the burners from the air-cooled front wall. A Detrick air-cooled front wall is installed through which secondary air is admitted. Heated air comes from a Dow air preheater, draft being supplied by motor-driven Sirocco forced draft fans.

Boilers No. 4 and No. 5 are 15,130 sq. ft. Wickes 3-drum bent tube boilers of the type shown in Fig. 4. Number 4 is equipped with a Dow preheater and No. 5 with a Ljungstrom 88,000-sq. ft. preheater. Both are supplied with pulverized coal by Aero unit pulverizers,

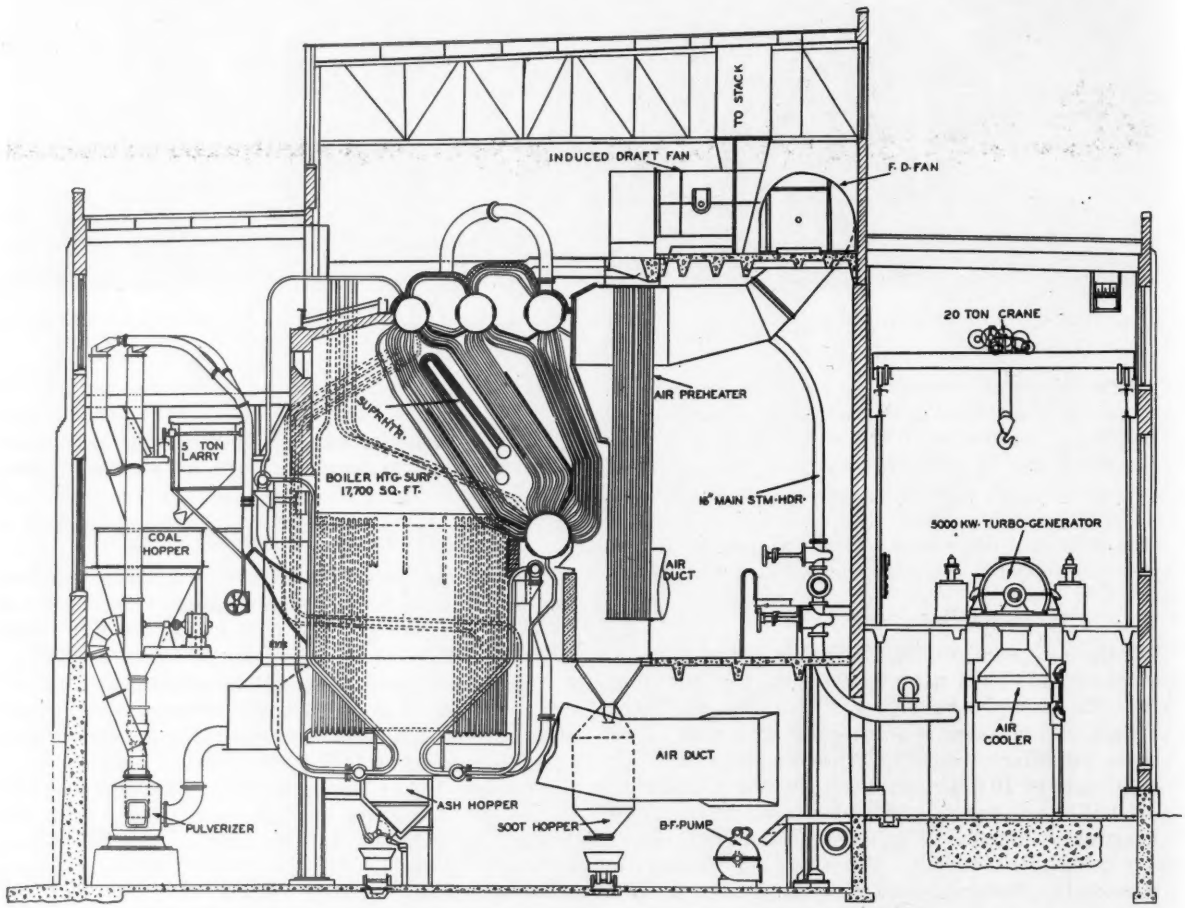


FIG. 3. CROSS-SECTION THROUGH PLANT AT BOILER NO. 6 SHOWING FURNACE DETAILS

two 4-t. mills per boiler supplying coal directly to Foster Wheeler burners in the front wall as shown.

Furnaces of Boilers 4 and 5

Furnaces of these units possess several points of interest. They contain a total of about 1000 sq. ft. of water-cooled surface. The side water walls are of Wickes construction consisting of bare 4-in. tubes backed by refractory, the tubes being partly recessed into the tile. A special drum at the top is provided to take some of the wall tubes; the others head into the regular steam drums of the boiler. At the bottom, the side wall tubes are led out to drums one of which is set as shown in Fig. 3. The rear wall below the bottom drum and the rear of the hopper bottom are of Foster Wheeler water wall construction, the part of the tubes in the hopper being armored. Sides and front of the hopper bottom have Bigelow-Liptak air cooled refractory walls and the front wall of the furnace is a Detrick air-cooled wall with air control dampers as shown. Foster Wheeler convection superheater is installed in the first boiler pass and the rear bank of vertical boiler tubes is baffled horizontally for three passes. Each furnace has a volume of 13,675 cu. ft., giving a ratio of heating surface to furnace volume of 1.1.

A Sirocco HS8½ forced draft fan on each unit is driven by a Crocker-Wheeler 75-hp. d.c. motor while the induced draft fan is a No. 9 Sirocco driven by a 125-hp. Crocker-Wheeler d.c. motor. Speed control of these fan motors is by shunt field rheostats actuated by the combustion control.

Boiler No. 6

Boiler No. 6 is a 17,700 sq. ft. Stirling Type XXIII unit, Fig. 3, equipped with B. & W. convection superheater and tubular type air preheater of 29,158 sq. ft. of surface, as shown.

Construction of the furnace is well illustrated in Fig. 3. The side walls are of the bare tube construction partly recessed into refractories, similar to that of Boilers 4 and 5 except that they connect at top and bottom to standard water wall headers instead of drums. Front and rear walls form the hopper bottom construction with completely water-cooled surface of protected tubes. This furnace has a volume of 12,940 cu. ft. giving a ratio of heating surface to furnace volume of 1.35 to 1. The total water-cooled surface of this furnace is 1896 sq. ft. It is designed for a maximum heat liberation of 22,300 B.t.u. per cu. ft. per hr.

Pulverized coal for No. 6 boiler is supplied by two Fuller Lehigh Co. table mills driven by direct-current motors. Exhausters on the firing floor remove the pulverized coal from the mills and send it to four Calumet coal burners in the front wall. All air for combustion is introduced at these burners, which are of the turbulent type. The air comes from the preheater at about 500 deg., the flue gas leaving at about 400, at a boiler rating of about 300 per cent. For drying coal in the mills, some of the air is tapped off as shown in Fig. 3.

Forced draft is supplied by a No. 9 Sirocco fan driven by a 135-hp. Crocker-Wheeler d.c. motor. Induced draft is furnished by a No. 10 Sirocco driven by a 275-hp. Crocker-Wheeler d.c. motor.

All of the above boilers are equipped with Diamond soot blowers, Stets feedwater regulators, Reliance water columns, Lunkenheimer blowoff valves and Everlasting blowoff cocks, Consolidated safety valves. Each boiler control panel carries a Bailey temperature recorder, Ellison draft gages, Republic steam and water meters, pressure gages and the necessary electrical pushbutton controls for pulverizer motors and auxiliaries.

Coal and Ash-Handling Equipment

Coal is unloaded from cars, crushed and elevated to bunkers over the firing aisle by skip hoists. One bunker has a capacity of 240 t., loaded by a 60-t. per hr. skip. The other has a capacity of 420 t. loaded by a 70-t. per hr. skip. From the bunkers coal is distributed to

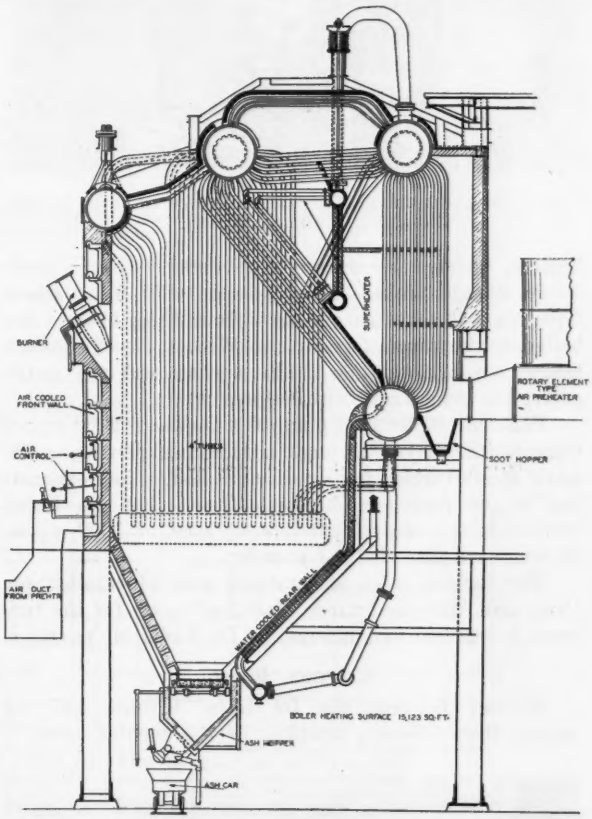


FIG. 4. CROSS-SECTION THROUGH TYPE OF BOILER USED FOR NOS. 4 AND 5

stoker hoppers and pulverizer hoppers by a 5-t. motor-operated weigh larry.

Ash from the furnaces drops into hoppers with water-sealed gates, from which the ash is dumped into industrial cars for removal from the plant. The ash gates at the bottom of each hopper are of special counterweighted construction with the operating lever arranged so that the operator stands entirely clear of any discharge from the gate. All coal and ash handling equipment was supplied by Beaumont Mfg. Co.

Boiler Feedwater Supply

Boiler feedwater comes from a central water softening plant made by the Graver Corp. This incorporates lime and soda and zeolite treatments. Water is heated to 212 deg. and deaerated in Wickes vertical open

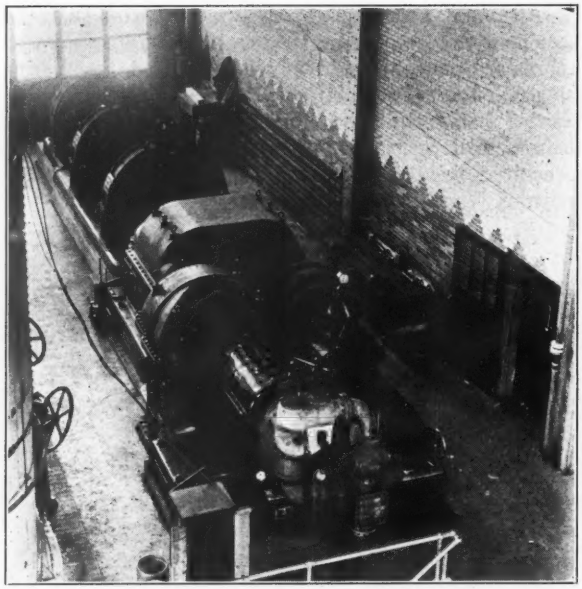


FIG. 5. THE TRIPLE-EXPANSION TURBINE DRIVES THREE GENERATORS IN LINE

heaters, which are continuously vented into the feedwater storage tanks. These operate with 8 lb. steam from the 8-lb. exhaust system. From these heaters the boiler feed pumps force it to Wickes closed heaters taking steam from the 150-lb. system and the water enters the boilers at about 350 deg. F.

The main boiler feed pump is a De Laval 2000 g.p.m. 6-stage unit driven through a reducing gear by a De Laval steam turbine taking steam at 350 lb. and exhausting to the feedwater heaters. Two other De Laval turbine-driven centrifugal pumps, each of 1000 g.p.m. capacity are provided for standby.

The turbine room is equipped with Harnischsfeger Corp. and Whiting cranes. Lubricating oil for the turbines is purified and filtered by De Laval oil purifiers.

Control Room

Midway between the De Laval turbine and the second Brown-Boveri machine in the turbine room is located a completely equipped control room, where distribution of power through the plant is carried out. Here are panels for the various turbine units carrying voltage regulators, electrical meters and the necessary switches. Power is distributed at the generator voltage, 2300 v. a.c. In this control room also are located steam flow meters, temperature recorders and other instruments that tell how the boilers are operating, so that the control operators have at hand all the necessary data.

The N-T power plant building itself is of brick and steel construction. The operating floors and working spaces are well-lighted by many windows in the daytime and by good artificial lighting at night. Piping and accessories are well cared for, there is every evidence of good housekeeping and turbine and boiler rooms present a most attractive appearance.

All power plant work of the Dow Chemical Co. is carried out by the engineering department of the company, in charge of G. A. Yocum, chief engineer, with L. J. Richards as his assistant, E. F. Holser as engineer in charge of work and M. Newkirk as superintendent of operation.

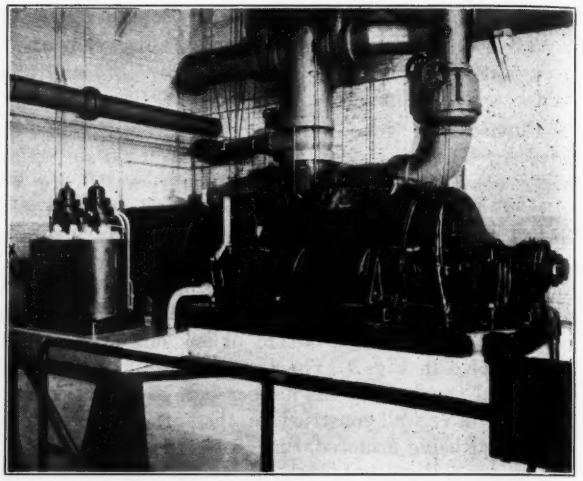


FIG. 7. THIS 5000-KW. BACK-PRESSURE TURBINE-GENERATOR RECEIVES ITS STEAM FROM THE 150-LB. STEAM SYSTEM AND EXHAUSTS TO THE 8-LB. SYSTEM

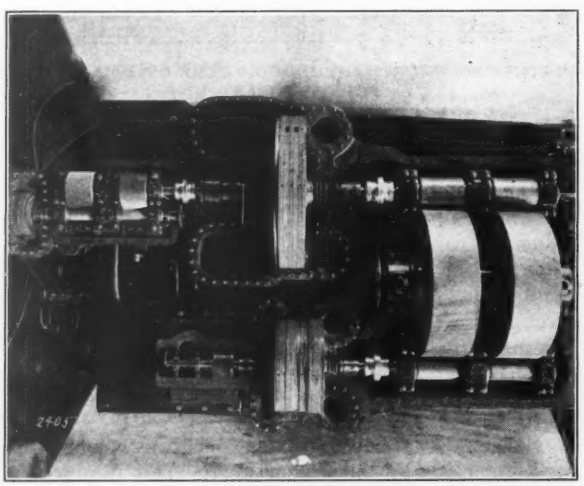


FIG. 6. LOOKING DOWN INTO THE TRIPLE-EXPANSION TURBINE. EACH ROTOR RUNS AT A DIFFERENT SPEED

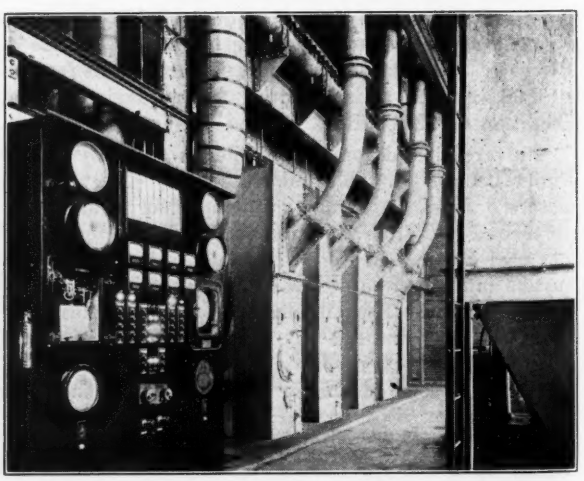


FIG. 8. FRONT OF BOILER NO. 6 SHOWING CALUMET BURNERS AND CONTROL BOARD

Equipment Record System Aids Maintenance Cost Reduction

KNOWLEDGE of the history of any piece of equipment aids materially in establishing proper procedure of maintenance for that equipment. In no simpler or more effective way can such history be assembled than by means of a card record system such as that illustrated. The necessary descriptive data is at hand at the time of installation of equipment and is easily recorded at that time; later some of this data may be obtained only with difficulty.

Customarily, maintenance costs are not kept accurately and it is difficult, usually, to obtain reliable data on the machine parts that need replacement. A system such as described offers a simple and convenient means of collecting exact maintenance costs, hence of analyzing those costs to determine the causes of trouble in excessive cases. This method also differentiates, as it should, between repair and replacement costs, separating labor and material costs.

Where an organization controls a number of power plants, equipment is sometimes transferred from one plant to another. In this case it is desirable not only to know, definitely where each piece of equipment is installed but to have available details concerning its installation, present worth and its characteristics. These requirements are met by the use of the equipment record card described. Means is also readily afforded for taking the annual inventory of equipment, a depreciation rate being set for each piece of equipment.

With a central equipment record, comparison may be made of the repair records not only of different units but of the different stations under one control.

In laying out an equipment record card, the name of the particular piece of equipment should be placed, for indexing convenience, in the upper right-hand corner and the name of the maker and the individual equipment number placed directly below the name of the equipment unit. General data is best entered on the upper part of the card. Specific descriptive data such as horsepower, kilowatts and voltage may be entered under remarks. Provision is made for indicating the name and equipment number of machines that are connected to the unit in question. For example, if an engine is connected to a generator, the word generator and its equipment number are entered in appropriate places. It is advisable to give an individual equipment number to each generator, exciter or similar equipment unit which may be connected to an engine. The lower part of the form is repeated on the back of the card to provide room for a larger number of entries. Where a maintenance log is kept, such as that described on page 437 of the April 15 issue, the various repair and replacement costs may be transferred from the log to the record card at the end of each month.

Equipment, in the first column, refers first to the unit itself, then to each replacement or attachment that is added. The various costs such as installation, repair, replacement and attachment, are separated for clarity. These are costs other than labor for which a separate column is provided so that, in the case of a repair, the labor cost is entered in the labor column and the material cost in the repair column. The column of Hours Laid Up is for noting the number of hours required to complete a repair or replacement or to connect an attachment. Reliable information on loss of operating availability of individual power units in power plants is usually unobtainable. With comparative information of this kind, more intelligent selection of equipment is possible. Dates on which all changes were completed are entered in the next column.

With the depreciation rate as a basis, the amount to charge off each year, the date on which depreciation is charged off and the value at that date, are entered each year. Appreciation, due to replacement or addition of an attachment, may likewise be entered.

EQUIPMENT RECORD CARD

Name of Instrument, Machine or Fixture

From Whom Purchased | Name of Maker

Location | Date Installed | Depreciation Rate | Connection with Equipment: Name, Number | Maker's Number | Our Number

Remarks

Equip.	Purchase: Date	Purchase: Price	Cost: Trans.	Cost: Labor	Cost: Install.	Cost: Repair	Cost: Replace.	Cost: Attach.	Cost: Total	Hours Laid Up	Date Change	Charge off for Depreciation: Amount	Charge off for Depreciation: Date	Present Value

EQUIPMENT RECORD KEPT ON 5 BY 8-IN. FILING CARDS IS EASILY MAINTAINED

Interlocking Coal Handling Systems

METHODS OF CONTROL TO PREVENT THE JAMMING OF COAL HANDLING SYSTEMS DUE TO FAILURE OF ONE ELEMENT IN THE SYSTEM. BY W. C. RAUBE*

IT IS THE PURPOSE of interlocking any electrically driven conveyor system to make certain that the various conveyors and machines in series with them are started and stopped in the predetermined order and to prevent damage and delay which might result from improper operation. In the power plant conveyor system to be discussed, it is easy to imagine the troubles which might be encountered without proper locking. An example might be overloaded and jammed

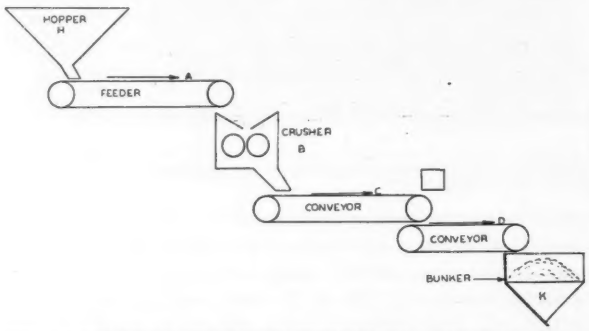


FIG. 1. DIAGRAM OF THE ELEMENTS OF A TYPICAL COAL HANDLING SYSTEM

belts, with possible broken or damaged parts, spilled coal and eventually the lapse of a great deal of labor before the belts are again "cleared" and placed back into service. Should the failure be sufficiently serious to run into a considerable delay before coal can be handled again, temporary conveying methods will have to be adopted with attendant high cost and inconvenience.

Obviously, there are innumerable ways in which interlocking can be applied, each for the purpose of making the combination of units perform safely and automatically in the desired manner. In this article, a typical power plant coal conveying system will be outlined together with two common interlocking arrangements.

TYPICAL SYSTEMS

Figure 1 indicates a typical conveyor system consisting of a feeder belt A, a crusher B, and two conveyors C and D with which it is proposed to handle coal from the hopper H to a bunker K. The arrows indicate the direction of flow of material through the conveyor system.

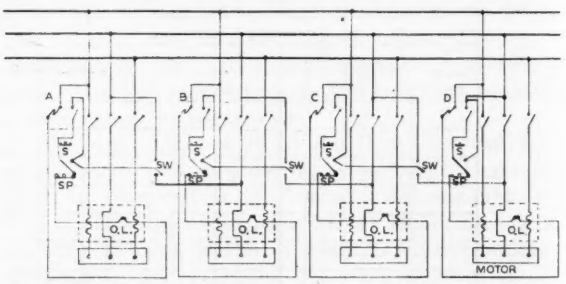
With such a system certain protective features should be incorporated, as follows:

1. Motors should be started in such order as to prevent dumping coal on a conveyor which is not running. This will require starting motor D first, then motor C, next B and finally A.

2. Stopping of any unit in the system should stop all other units delivering coal to that unit. For example, if conveyor C should stop for any reason whatsoever, it should not be necessary to stop conveyor D but it would be exceedingly desirable to stop crusher B and feeder A since, if these two drives were to continue delivering coal, conveyor C would soon be flooded at the point where the crusher discharges onto conveyor C.

3. Provision should be made for independent operation of the various units to facilitate making tests and inspections.

Figure 2 shows an elementary wiring diagram for the control of such a conveyor system as outlined above. With this scheme, each motion has its own "start-stop" push-button station. With the control switches SW set for normal interlocking, however, conveyor C cannot be started until power is on conveyor D, crusher B cannot be started until power is on conveyor C and feeder belt A cannot be started until power is on crusher B. The above sequence of starting is made certain by the fact that the control energy for conveyor C, for example, cannot be obtained until after the main line contactor for starting conveyor D has been closed. The proper sequence starting of crusher B and feeder belt A are made certain, likewise, with the completion of their control feed circuits by the closing of the line contactors for conveyor C and crusher B respectively. Such



S-START SP-STOP
OL-HAND RESET THERMAL OVERLOAD RELAY
SW-SINGLE POLE DOUBLE POLE TRANSFER SWITCH TO PERMIT INDEPENDENT OPERATION OF MOTORS A-B OR C WITHOUT INTERFERENCE OF NORMAL INTERLOCKING. WITH SWITCHES DOWN NORMAL INTERLOCKING IS OBTAINED. WITH SWITCHES UP INTERLOCKING IS SHORT CIRCUITED.

FIG. 2. ELEMENTARY WIRING DIAGRAM FOR THE CONTROL OF A COAL HANDLING SYSTEM SUCH AS SHOWN IN FIG. 1

wiring therefore provides the interlocking as set down under point 1 above.

An examination of the wiring circuits further reveals the fact that, when the four units of the conveyor system are operating, it is impossible to continue to operate units which are delivering coal to a unit which has stopped because an overload relay has tripped or a "stop" button has opened. As a typical case, let it be assumed that the overload relay is tripped in the C conveyor control. Such operation would cause contactors C_1 to open and to interrupt power to conveyor C motor. The opening of contactor not only interrupts power for conveyor C motor but also the L_2 side of the control feed for contactor B_1, thus causing B_1 to open

*Industrial Engineering Dept., General Electric Co.

which in turn interrupts power to the crusher motor. Of course, the opening of contactor B_1 also interrupts the L_2 side of the control feed for contactor A1, which causes contactor A1 to open and disconnect power from the feeder belt motor A. Motors C, B and A have therefore been stopped directly by the tripping of the overload relay on control panel for conveyor C motor. Similar operation would have resulted from the opening of the "stop" push-button station wired in the control of conveyor C motor. The interlocking protection set down under point 2 above is therefore satisfactorily taken care of in the wiring scheme as shown in Fig. 2.

Where It Is Desirable to Operate Units Independently

Although proper interlocking is imperative for normal operating conditions, it is sometimes equally

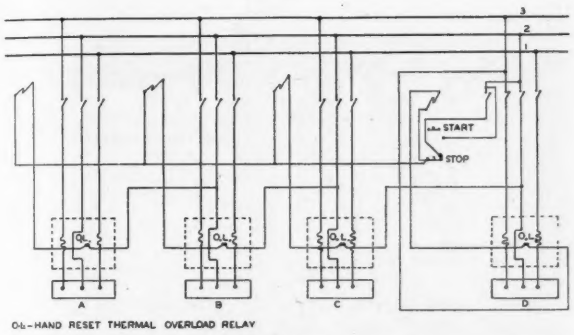


FIG. 3. ANOTHER WIRING DIAGRAM FOR AN INTERLOCKING SYSTEM IN WHICH ANY UNIT CAN BE OPERATED INDIVIDUALLY

desirable to be able to operate conveniently and independently any unit of the conveyor system for testing or inspection as suggested under point 3. This feature can be readily incorporated in the control scheme shown in Fig. 2 by the addition of three single-pole, double-throw control switches SW connected as indicated. Normal operation providing the interlocking feature is obtained when these control switches are closed in the "down" position as indicated on the wiring diagram. To eliminate the interlocking feature, these switches need only be closed on their upper pole, thus making it possible to operate any unit entirely independently of any of the other units in the system.

The equipment required to provide the interlocking desired in this particular case is not special, therefore it can be incorporated in a new installation or can be readily adopted in existing non-protected installations.

An alternative wiring arrangement as shown in Fig. 3 is also frequently used on power plant conveyor systems. In this scheme, the essential difference over the arrangement shown in Fig. 2 is that the units are all started when a single "start" button is pressed. Applying this scheme of connections to the 4-unit scheme that has been used above, conveyor D would be started directly when the "start" button is pressed. Conveyor C, crusher B and feeder A are automatically started in sequence following the closing of the main line contactor of the preceding motion. Only one "start-stop" push-button is shown but additional stations may be provided. Any additional "start" buttons must be wired in parallel with the "start" button already shown and any additional "stop" buttons would have to be wired in series with the "stop" button already shown. The "stop" button as shown connected will simultaneously stop all four motions of the system. The overload relays are shown connected with their respective control panels, hence the tripping of the overload relay on control for motor B will have no effect on motors C and D directly or indirectly but will be directly responsible for the tripping of the line contactor for motor B and indirectly will cause the contactor for motor A to open after the contactor for motor B has opened.

The interlocking outlined above has been shown on the basis of alternating-current installations, because of the wide use of this form of power in such installations. Equally effective interlocking can be provided on direct-current installations with the use of proper electrical interlocks on the various control devices.

It will also be noted that the alternating-current connections shown are on the basis of high-starting-torque squirrel-cage motors and across-the-line starters which are commonly used for conveyor service. Interlocking can also be arranged, however, with other types of alternating-current motor drives with equal effectiveness. The individual control panels for the various units may not be as simple as indicated in the wiring diagrams but the interlocking connections should not be any more complicated than the interlocking schemes shown.

Duplex Motor Drives

By W. E. Warner

When two motors are connected to and drive the same power unit, the motors working in parallel and sharing the load between them, the arrangement is known as duplex drive. In some cases, both motors are direct coupled to the power unit, in others both motors drive a common pulley by means of belts. To obtain satisfactory results from a drive of this kind, the full and no-load speeds and the speed characteristics of both motors must be the same. They must also be kept in perfect condition since if one motor fails to take its share of the load, it may cause the other to be overloaded.

In direct-current motors, the condition of the commutator and brushgear should be watched, as commutation faults will cause a motor's load carrying capacity to fall. Attention should also be paid to the air gaps since if these are unequal the speed will be affected. If one of the motors becomes overheated, the most probable cause is that it is overloaded through the other motor failing to take its share of the load.

Where motors are connected to a common pulley through two belts, care must be taken that both belts are of equal tension and that both are properly joined, as slip through either of these causes would affect the sharing of the load.

Where induction motors are used, the problem of slip presents itself. Slip is the amount the actual speed of the motor differs from the synchronous speed, the amount of slip varying in different types of motors, therefore upsetting the speed calculations. The motors should therefore be identical as regards slip. The

sharing of the load would also be affected by inequality of the air gaps or through the rotor not being correctly centered in its stator. The windings should therefore be frequently tested electrically so as to detect faults as they develop.

Regulation of Temperature and Pressure in Textile Mills

By Charles J. Wilder

ONE OF the major requirements of the textile industry is close regulation of temperature and pressures of steam and water used in the process. The equipment used for maintaining given conditions must be positive, rugged and accessible for adjustment.

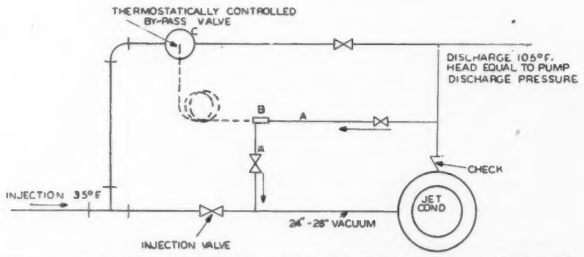


FIG. 1. ARRANGEMENT FOR MAINTAINING CONSTANT DISCHARGE TEMPERATURE FROM A JET CONDENSER

One method used successfully on a number of machines for maintaining a constant temperature of the condenser discharge water of extraction turbine is shown in Fig. 1. The line AA is a small bypass line containing the thermostatic element B.

As the steam flow through the condenser increases because of increased electric load or lessened extraction steam demand, the temperature of the condenser discharge increases, actuating the thermostat which in turn closes the thermostatically controlled valve, C, in the main bypass line and increases the flow of cold injection water to the condenser. The temperature can be controlled at will by the operator.

As piped, the flow through the small bypass with the thermostatic element is considerable because the pressure differential between the inlet and exit end is the difference between the discharge head of the tail pump and 24 to 26 in. of vacuum. This flow gives an almost instantaneous indication of temperature changes in the discharge water and operates the bypass valve to keep that temperature constant.

The difference between the cooling water temperature range, 35 to 105 deg. F., and the temperature to which the thermostat would be subjected in case the vacuum was lost, that is 214-216 deg. F., is considerable and would rupture the element if it were placed directly in the discharge line.

Should an accident of this kind happen early Monday morning, the temperature control would of necessity be out of service until Saturday afternoon when the machine would be shut down. With the element installed in the bypass, a misfortune of this kind could be remedied in 20 min. without interfering with the operation of the turbine. Spare elements are always kept on hand.

Another device used successfully to improve the speed regulation of a 3000-kw. extraction turbine is shown in Figs. 2 and 3. Just as increased back pressure tends to lower the speed of a reciprocating engine, so does increased extraction pressure tend to slow up an extraction turbine.

By various levers, diaphragms and bell cranks, the modern mixed and extraction turbine governor will maintain close regulation under varying conditions.

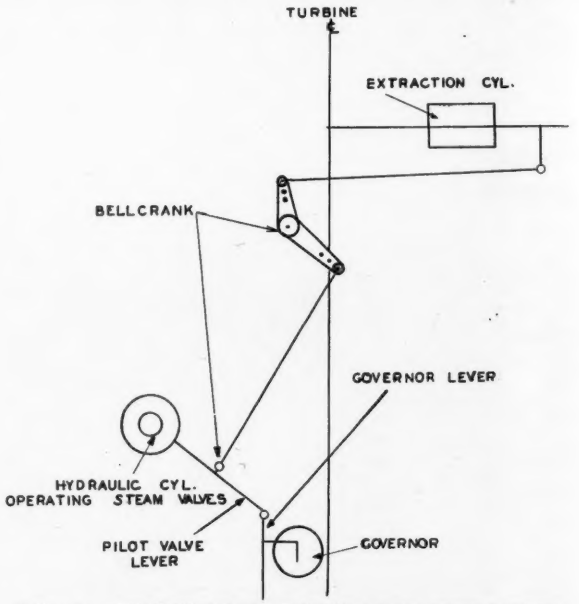


FIG. 2. COMPENSATING DEVICE FOR EXTRACTION TURBINE GOVERNOR GEAR

Many of the older machines, however, are not fitted with governors of this type and the regulation is not always of the best.

By clamping an arm on the piston rod of the extraction cylinder and carrying the motion through one horizontal bell crank to a spring attached to the pilot valve lever as shown diagrammatically in Fig. 2, satisfactory regulation may be obtained.

The actual arrangement of the bell crank is shown in Figs. 2 and 3. The spring B of Fig. 3 A is inserted between the bell crank and pilot valve lever. As shown

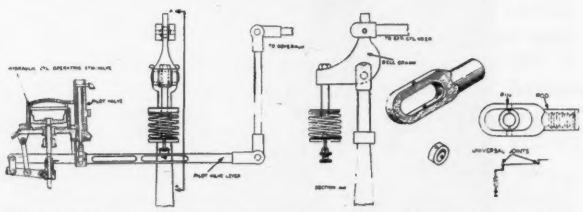


FIG. 3. (A) AND (B) BELL CRANK AND SPRING CONNECTING THE COMPENSATOR TO THE PILOT VALVE LEVER. (C) DETAIL OF THE CONNECTION WHICH ALLOWS FREE MOVEMENT OF THE PILOT VALVE LEVER WHEN NOT EXTRACTING

in the detailed section, this spring arrangement allows the pilot valve lever to rise unmolested when the extraction gear is not working. Under these conditions, the bell crank would be down and unless such an arrangement were made the bell crank would interfere with the action of the governor.

Mechanical Problems of BOILER WATER TREATMENT

1500 Test Samples Show the Effect of Boiler Circulation on Blowdown, Deconcentration and Concentration Problems. Boiler Operated Satisfactorily with a Total Solid Concentration of Around 1100 Gr. per Gal. By Julian E. Tobey*

CORRECTING a serious water problem in an industrial power plant having a boiler feed make-up of approximately one million gallons per day by reverting to internal treatment involved an extensive study

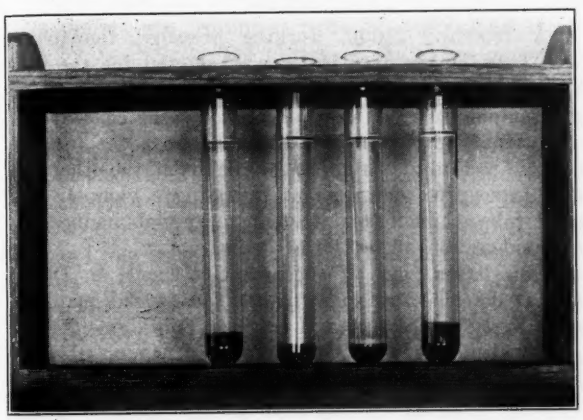


FIG. 1. SAMPLES OF BOILER WATER BEFORE (NO. 1) AND AFTER (NO. 4) BLOWING DOWN 3000 GAL.

of the characteristics of this type of treatment. Looking forward at the problem, the most important issue appeared to be the chemical phase; looking backward, this part was overshadowed by the mechanical features of the problem involving the boiler circulation.

With internal treatment, this plant found it possible and beneficial to carry a concentration in the boilers approximately three times as great as had been possible with external treatment, that is 40-60 gr. per gal. That this could be done, considering the suspended solids—dissolved solids ratio was much higher with internal than with external treatment, indicated an unusual and interesting condition.

Obviously with the same total solids concentration in the boiler, as was maintained previously while using external treatment, the boiler water was much more heavily loaded with suspended matter. That it was possible to triple this concentration and produce very clean steam, whereas formerly dirty steam had been produced, was remarkable in itself. Having established the fact that higher concentrations produced cleaner boilers, it was decided to maintain consistently within a close range a certain degree of concentration in the boilers.

It was found to be extremely difficult to maintain the concentration at a predetermined point, and curves plotted on the concentration in each boiler showed it to be erratic. Many things, such as boiler rating, water level, blowdown and leaks affected it. Serious consideration was given the matter of blowdown and it became apparent that ordinary blowdown and deconcentration could not be properly considered as synonymous terms.

Early in this study it was found necessary to use the continuous blowoff method for properly controlling the concentration. Tests were made which proved that certain large boilers which were operated at high ratings could not be successfully deconcentrated by opening the blowoff valves according to the customary procedure; however, it was found that if the boiler was operating at a rating sufficient to maintain a good circulation, a miniature leak in one of the blowoff valves would then very effectively reduce the concentration in the boiler.

The explanation for this is that it is necessary to drop to a low rating while the main blowoff valves are being used and as the boiler holds more water at low ratings, due to the reduction of the steam—water emulsion in the tube banks, the deficit of water is made up of fresh boiler feedwater, which, on account of its density (lower temperature) and downward flow, coincident with the circulation decelerating, goes to the lowest point in the boiler and is deposited directly over the blowoff connections.

Feedwater Short Circuits to the Blowoff

When the blowoff valves are opened fresh water is blown out of the boiler instead of concentrated water. Consequently the blowdown operation is not effective but simply results in the wastage of water. This cycle is so perfect that in a test case approximately 3000 gal. of water were blown from a bent tube boiler at one time without any reduction in concentration. Samples taken before the rating was reduced and again after it had been restored showed that the total solids had increased from 743.5 to 749.5 grains per gallon.

These samples are represented by test tubes Nos. 1 and 4 in Fig. 1 (these show the suspended solids). Tubes Nos. 2 and 3 show respectively the diluting effect which occurred while the rating was reduced before and after blowdown. These four samples were taken from the upper middle drum and indicate that the water entering the boiler during this period not only was deposited on the bottom of the mud drum but that a portion of it went into circulation and had a diluting effect upon the boiler water proper. When the rating was restored to its previous point, this dilution dis-

*Chief Engineer of Power Plants, Studebaker Corp. of America, South Bend, Ind.

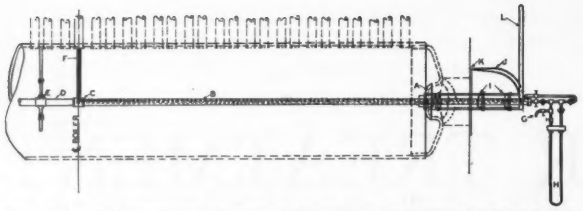


FIG. 2. DETAILS OF DEVICE USED FOR EXPLORING THE BOILER DRUM

appeared. The reason for its disappearance was that the boiler again contained the same amount of water that it held before the rating was reduced and as there had been no deconcentrating effect upon the water during the blowdown operation there was naturally a slight increase in concentration, corresponding portionally to the amount of water evaporated during the 1 hr. period.

It was noted that after the blowdown period the floc in the water was of slightly lighter nature, apparently the process of dilution had a regenerative effect on it. Test tube No. 4, Fig. 1, shows that the suspended matter occupies considerably more volume in proportion than it does in test tube No. 1 although there was little difference by weight when evaporated to dryness.

Is the Lower Drum Correctly Named?

These and other findings cast a doubt as to whether the lower drum should be called the mud drum in the strict sense of the word. For instance, another test showed that it required approximately six hours for the suspended matter to settle appreciably into the lower drum after the fire had been completely removed from the stoker and the boiler taken off the line. This indicated that the residual heat in the setting was sufficient to maintain a circulation adequate to carry the suspended matter for a considerable length of time.

In order to obtain further knowledge of the subject it was decided to conduct a complete concentration test to determine specifically the behavior of the dissolved and suspended solids particularly in relation to each other and to learn whether the concentration of the solids was uniform or definitely zoned in the boiler and if zoned in what manner. Six different attempts were made to conduct such a test but in every case they were not completed on account of some unstable condition which would have had a serious effect on the accuracy of the data. The seventh test was successfully completed and an account of it follows.

Test Apparatus

A 1500-hp., 210-lb. working pressure, four-drum, bent tube, stoker fired boiler was selected for the test. Special devices were installed in the boiler for obtaining samples from different locations. One consisted of a stationary pipe which extended through the head to the mid-section of the upper middle drum, the other was a rotative pipe arrangement including a sampler and pitot tube which passed through a special manhead to the mid-section of the lower drum.

This latter piece of equipment is shown in Fig. 2 and is described as follows: A is a special manhead with a stuffing-box; B a 2-in. brass pipe extended to pitot tube block C; D an extension passing through bearing E, E being held central by a special spider in

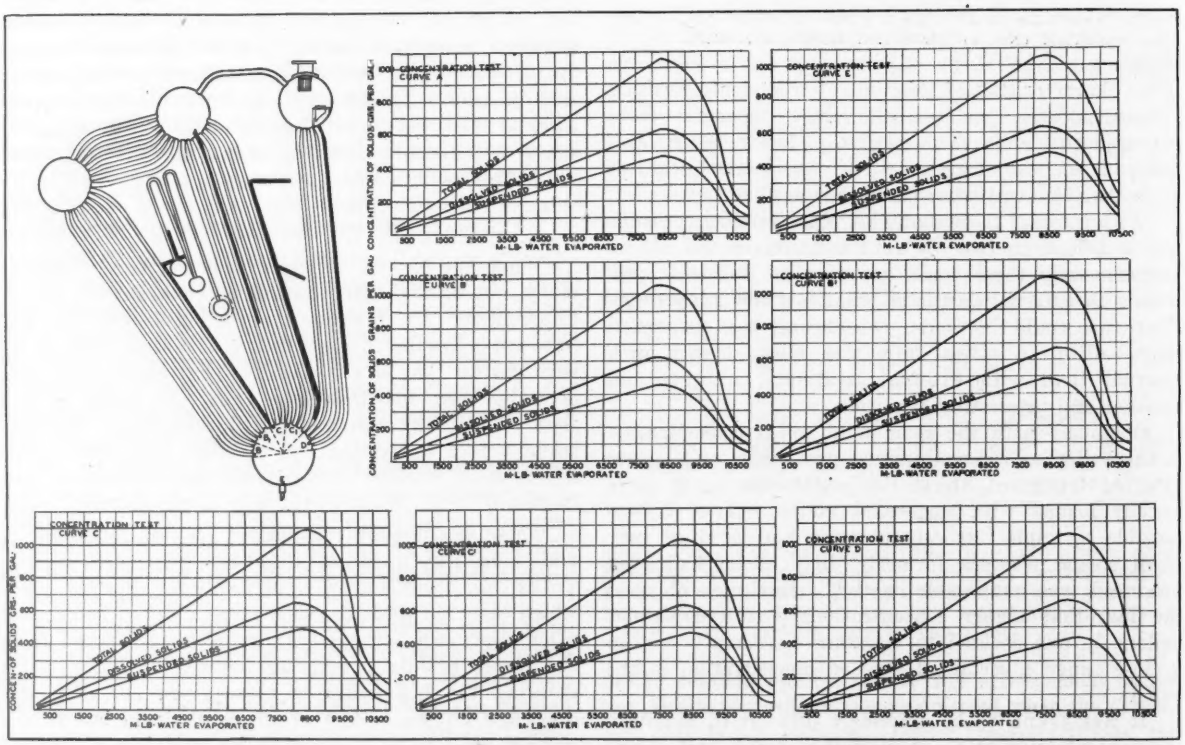


FIG. 3. SAMPLING LOCATIONS ON A 1500-HP. BOILER, AND TEST RESULTS SHOWING THE CONCENTRATIONS IN BOILER WATER AFTER DIFFERENT PERIODS OF OPERATION. LETTERS ON THE CURVES DESIGNATED SAMPLES TAKEN FROM THE LOCATIONS SIMILARLY MARKED IN THE SECTIONAL DRAWING

the drum as shown. F is a pitot tube which is adjusted to clear the tube ends by ⅛ in. The pitot tube tap connections extend through pipe B to the outside of the boiler. G is a spigot from which samples of boiler water were drawn, one connection of the pitot tube acting as a sample pipe. H is a U-tube connected to the pitot tube F. I denotes clamps and thrust plates for holding the apparatus in proper lateral position. J is a pointer used in conjunction with quadrant K for indicating the position of the pitot tube F and L is a lever clamped to pipe B for rotating the pitot tube to various tube end centers.

For deconcentrating purposes, a ½-in. bleeder was installed on one of the blowoff connections and condenser coils were used to eliminate the flash when samples were drawn. Approximately ten gross of 1-pt. glass bottles with caps were required to contain the samples. Laboratory facilities and field testing apparatus were used for determining the concentration data. The boiler was equipped with a continuous steam sampler to indicate the purity of the steam generated and a throttling calorimeter was used to determine steam quality.

Procedure

Starting with a boilerful of fresh treated water the concentration was gradually increased until it reached approximately 1050 grains per gallon total solids as shown by samples taken from the upper middle drum. It was then decreased gradually by means of the small bleeder until it approached the initial point. Samples were taken, at 4-hr. intervals, from seven fixed points in the boiler designated as A, B, B_1, C, C_1 and E as shown in Fig. 3. From the gravimetric analysis of the samples, curves were plotted to show the concentration of suspended, dissolved and total solids during the ascending and descending phases of the test.

These curves, Fig. 3, were labelled A, B, B_1, C, C_1, E referring to the sampling points which they represented. In order to increase the concentration at a definite rate the boiler was operated at a constant rating which equaled 200 per cent of normal except during cleaning periods. This also had a stabilizing effect upon the volume of water in the boiler, an important condition. It required 132 hr. to build the concentration up and approximately 12 hr. to reduce it as shown on the curves.

During the entire time, the blowoff valves were blanked to prevent any leakage. No water was fed to the boiler from the auxiliary feed system as this would have entered through the blowoff connection and produced a disturbing effect upon the concentration. During the test, an attempt was made to compare the velocities at the various tube ends in the lower drum by means of the pitot and "U" tube apparatus previously described.

Discussion of Results

A comparison of curves in Fig. 3 reveals that the boiler water as a whole was almost homogeneous. Of striking significance is the comparison of curves A and E which represent the top and bottom of the boiler respectively as samples E were taken from within ½ in. of the bottom of the drum.

Curves A and E correspond perfectly and prove that in spite of the great load of suspended solids which the boiler water carried there was no general settling action toward the lower drum at any time during the 144 hr. in which this test was in progress. Had there been a settling action, the dissolved-suspended solids ratio would not have remained constant but instead curve A would have shown a decrease of suspended solids whereas curve E would have shown a marked increase in suspended solids.

All curves show that approximately the same ratio existed in the water at the conclusion of the test as at the beginning. Although there is a close resemblance of all curves, slight differences are to be noted in some of them, namely B_1, C and D. Curve B_1 shows that the highest concentration in the mid-section of the boiler existed at point B_1; this condition obtained consistently. Curve C also showed the same characteristic although slightly lower values. As the highest concentration is obtained at the end of the longest travel from the source in the hot zones, this raises a question as to circulation in this section of the boiler.

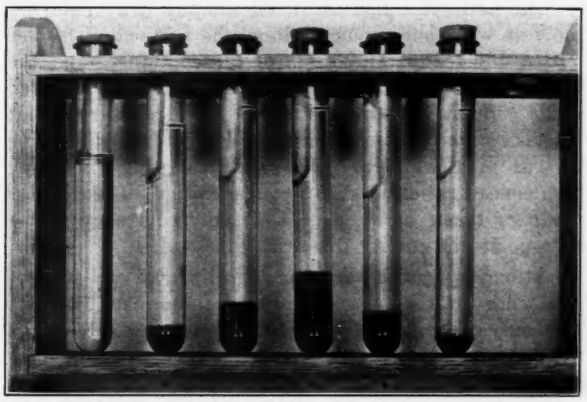


FIG. 4. SAMPLES TAKEN AT DIFFERENT PERIODS OF THE TEST. NO. 4 HAS A CONCENTRATION OF 1164 GR. PER GAL.

Two Way Circulation in the Rear Bank

Curve D is a surprise, for it shows consistently as high concentration as several other curves. It was assumed that samples taken from point D would show a fresh water concentration as it is located in the rear bank, for there are no water circulating tubes between the middle and rear drums. Finding no evidence of fresh water at point D, although the boiler was taking water at the rate of approximately 200 g.p.m. throughout the test, indicates that there existed two lateral circulations in the rear bank, namely down at the ends and up in the middle. As the gases are always hottest in the mid-section of a boiler, this would have the effect of stimulating such a flow.

A few typical samples were selected from approximately 1500 to tell the story visually, showing the relative suspended solids content of the boiler water during the ascending and descending phases of the test. These samples in test tubes are shown in Fig. 4. Test tube No. 1 contains boiler feedwater with which the boiler was filled at the beginning of the test. This water had a hardness of 9.6 gr. per gal. of which approximately 7 gr. were sulphate and 2.6 gr. carbonate.

The total solids content was 15.77 gr. per gal. The regular internal treatment was used throughout the test to condition the boiler water.

1100 Gr. per Gal. Highest Concentration

Tube No. 2 contains boiler water and shows the relative amount of suspended solids after 760,000 lb. of water had been evaporated. Tube No. 3 is boiler water after 3,040,000 lb. evaporation. Tube No. 4 is boiler water after 8,200,000 lb. evaporation and represents the highest degree of concentration obtained (1100 gr. per gal. total solids, 435 gr. suspended solids and 665 gr. dissolved solids). Immediately after this sample was obtained, the process of deconcentrating the boiler water was commenced. Tube No. 5 is boiler water after 9,120,000 lb. evaporation (deconcentrating condition). Tube No. 6 is boiler water after 10,640,000 lb. evaporation and represents the condition of the water at the termination of the test.

One noticeable feature in all samples drawn during the test was that, upon cooling, the suspended matter settled quickly to the bottom of the containers and the water became crystal clear regardless of the dissolved solids content. Clean steam was produced throughout the test. Evaporated samples of steam showed it to be just as pure while the boiler was carrying extremely high concentration as at low concentration. Calorimeter readings taken at regular 4-hr. intervals showed the average steam quality dry and saturated.

Attempts to compare the velocities at the various tube ends in the lower drum were complete failures. The only information derived was that the velocities were so low that a pitot tube with its tip within one-eighth of an inch of the tube ends would produce no noticeable deflection on a "U" tube in which a dark liquid slightly heavier than water was substituted for mercury.

Although its object was rather simple, this test required an immense amount of background and effort throughout to conduct it successfully. The laboratory work was exacting and, due to the great number of water samples evaporated to dryness, the work was tedious. A mass of supporting data was collected during the test, none of which is shown in this article.

Conclusions

1. The effect of gravity on the solids in the boiler was counteracted by the circulation, thereby preventing stratification.

2. The boiler can be successfully deconcentrated by a small bleeder connected to any point in the boiler with the exception of that point where the fresh water enters, the ideal location being point B_1 as shown in Fig. 3.

3. The test indicates that there are lateral and auger-like movements of the water from the ends toward the middle of the boiler and vice versa.

4. When properly treated, boiler water can carry an unusual amount of both dissolved and suspended solids and still produce clean steam. The writer believes there is a direct relation between boiler water which settles clearly (as shown in Figs. 1 and 2) and clean steam.

Temple of Power for Chicago World's Fair

CIRCULAR BUILDING of monumental proportions, possibly covering an area of several hundred thousand square feet, to contain a series of theatres with revolving stages, has been proposed for the electrical exhibits at the Chicago World's Fair in 1933. The proposal is contained in a report made by a group of leading electrical engineers to Dr. Frank B. Jewett, president of the Bell Telephone Laboratories, who is chairman of the National Research Council Science Advisory Committee, under the auspices of which the science exhibit plans for the exposition are being developed. The sponsors of the plan have suggested that the building be called the Temple of Power.

It is planned to show exhibits of electric generation at one end of the building; at the other end, covering at least half of the entire building and also some of the open space, either on the outside or in an open court, it is expected that all the various applications of electricity in the home and in industry will be shown. The space between these two is to be devoted to exhibits showing transmission, conversion and distribution of electricity.

Utilization exhibits, according to the plans, will be exhibited on the rotating stages, which are considered the most prominent feature of the Temple of Power.

The generation exhibits, the report states, will be mainly in the form of quarter size models and will show equipment from coal pile, river or oil tank, to switchboard. It is planned to show a steam station with all of the principal auxiliaries, a hydroelectric station, and also an internal combustion plant.

For the distribution exhibits it is proposed to set up a miniature power system, including high voltage power lines, intermediate voltage pole lines, overhead and underground distribution systems, and various types of conversion substations.

It is also planned as a spectacular feature, to arrange for lightning hitting 220,000-v. lines to illustrate what engineering has done to minimize this enemy of transmission.

Members of the electrical engineering committee include: R. F. Schuchardt, chairman; W. A. Durgin, John F. Gilchrist, E. W. Lloyd, L. A. Ferguson, all of the Commonwealth Edison Co. of Chicago; H. W. Fuller, Byllesby Engineering and Management Corp., Chicago; Samuel Ferguson, Hartford Electric Light Co., Hartford, Conn.; H. A. Barre, Southern California Edison Co., Seattle, Wash.; T. D. Crocker, Northern States Power Co., Minneapolis; W. E. Funk, Philadelphia Electric Co., Philadelphia; C. F. Hirschfeld, Detroit Edison Co., Detroit; W. S. Lee, Duke Power Co., Charlotte, N. C.; A. H. Markwart, Pacific Gas and Electric Co., San Francisco; W. E. Mitchell, Georgia Power Co.; I. E. Moultrop, Edison Electric Illuminating Co., Boston; J. C. Parker, Brooklyn Edison Co., Brooklyn, N. Y.; G. E. Quinan, Puget Sound Power and Light Co., Seattle; E. C. Stone, Duquesne Light Co., Pittsburgh; Philip Torchio, New York Edison Co.; W. S. Barstow, New York City; J. L. Hecht and H. H. Field of Chicago and F. R. Moulton, Utility Power and Light Co., Chicago.

Feedwater Regulation for Modern Boilers

PROBLEM OF CONTROLLING BOILER WATER LEVEL HAS BECOME COMPLICATED IN BOILERS WORKED AT HIGH RATING AND WITH SMALL WATER SPACE

ADVANCES made in the design of boilers, increases in steam pressure now becoming common, higher rates of steaming in modern practice, rapid fluctuations in loads placed on steam boilers, quickly regulated furnace conditions made possible by the extensive use of pulverized fuel, oil, gas and modern stokers, have all

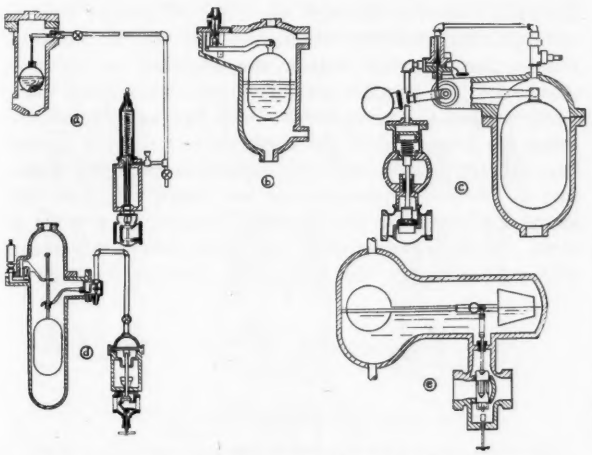


FIG. 1. FLOAT TYPE FEEDWATER REGULATORS

a. Float controls steam to spring loaded, piston operated regulator valve. b. Float operates steam valve in separate chamber from column. c. Control of steam to the feed valve is through valve entirely outside water column. d. Rising float admits steam to operating valve chamber, closing exhaust valve and admitting steam under pressure to close regulator valve. e. Counterweighted float operates valve directly through link and rod.

contributed to complicate the problem of feedwater regulation. Exeeding either the high or low water limit presents dangers far greater than those encountered in years past and at the same time the difficulty of holding the water level within proper limits has been greatly increased.

When the water level is carried too high in a boiler, moisture and even slugs of water are likely to be carried over to the steam piping or superheater with attendant danger of water hammer and scale accumulation. Low water level causes overheating of the boiler metal in the upper heating surface with resultant danger of weakening boiler metal, cracks due to sudden cooling, leaks and rupture of the boiler.

EFFECTS OF LOAD FLUCTUATIONS ON WATER LEVEL

Complications start when suddenly fluctuating loads are encountered. Suppose, during normal operation, a sudden increase of load is demanded or that the safety valve pops. The resultant slight drop in steam pressure in the boiler is immediately followed by increased steam generation due to the heat stored in the boiler water, with this action will come an elevation of the water level due to the increased volume of the steam bubbles in the boiler water. With a feedwater regulator that derives its control from the water line only, the flow of water during this first rush of steam demand will be completely shut off. Again, with a sudden decrease in load, the water level drops because of the decreased volume of the steam bubbles and a sudden increase in the flow of water to the boiler results.

Early designs of feedwater regulators worked on the principle that the water level must be maintained within narrow limits which resulted in intermittent flow with the feed valve either wide open or tightly closed. With widely varying loads and the relatively smaller water space in modern boilers, this intermittent feeding caused uneven steam generation and in batteries of boilers intermittent feeding will cause the load to swing from one boiler to another with resultant unsatisfactory operation. Continuous flow feedwater regulators have, therefore, been developed to overcome this difficulty. With these, the feed valve is closed only when the water level is at or above the maximum desired and the opening varies to suit the load on the boiler. Fluctuations in

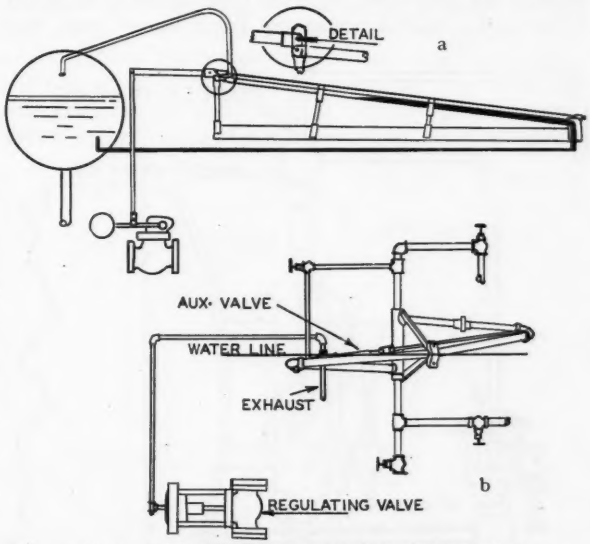


FIG. 2. EXPANSION TUBE TYPE REGULATORS

a. Expansion and contraction of tube operates valve through levers and rods. b. Expansion and contraction of tube controls opening of auxiliary steam valve in the line to the regulating valve.

load will, of course, cause momentary variations in water level due to the varying volume of steam bubbles in the boiler water but continuous feeding results in more even boiler pressure and better steaming characteristics.

Improper feedwater regulation may result in the boiler water level being too high or too low, cause unnecessary variation in steam generation or steam pressure; cause priming, variation in level throughout the boiler and uneven load distribution among boilers in a battery.

FEEDWATER REGULATORS

Inasmuch as the water level in a boiler is affected by several operating conditions, various means have been devised for controlling the flow of water to the boiler.

One of the earliest and still extensively used devices is a float actuated value. The float is placed in a water column, the water level in which rises and falls with the water level in the boiler. The float is connected either mechanically or through steam piping to the feed valve in such a way as to open the valve when the water is low and close it when the water rises. This actuating mechanism is positive, gives continuous feed under steady

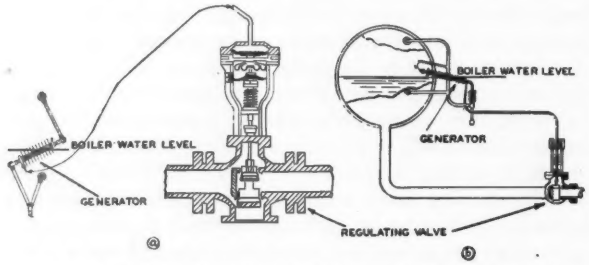


FIG. 3. THERMO-HYDRAULIC TYPE REGULATORS
a. Employs diaphragm type valve. b. Valve operated by sylphon bellows.

loads and under suitable load conditions on boilers having large water capacity it will maintain the water level well within the safe limits.

Another device uses the expansion of a metal tube to actuate the feed valve, with the tube placed at an angle between the desired upper and lower water levels, the

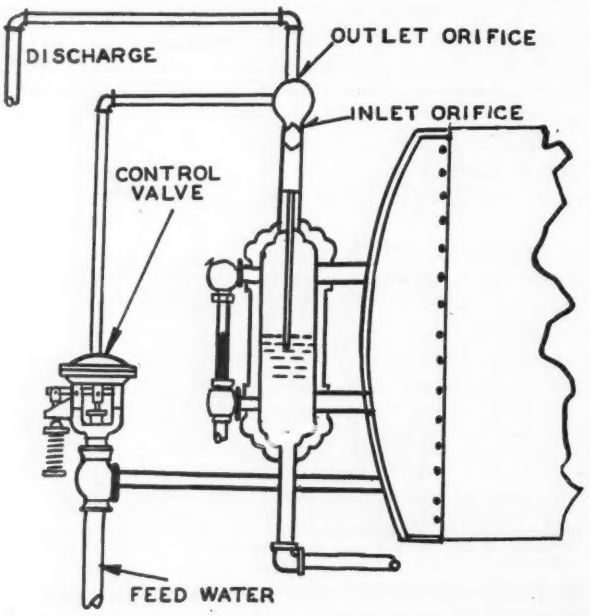


FIG. 4. OPERATION OF THIS REGULATOR DEPENDS UPON FLOW OF STEAM OR WATER THROUGH ORIFICE INTO EXPANSION CHAMBER

upper end being connected to the steam space of the boiler and the lower end to the water space. A lowering of the water level will cause more steam space in the tube, raising its temperature in that section and increasing its length proportionally. This expansion is utilized through compounding levers or steam valves to operate the feed valve. Such a device will give continuous flow of feedwater as long as the level is below the desired maximum, the flow varying from maximum at low level to minimum at high level.

Difference in temperature between the water and vapor in a column connected at top to the steam space and at bottom to the water space in a boiler, is used to vaporize a liquid in a jacket surrounding the column, thus causing a variation in pressure within the jacket due to varying boiler water level and by communicating this pressure to a diaphragm or sylphon operated valve, the flow of water is controlled in accordance with the need for water in the boiler.

In another type, the pressure created by water flashing into steam is employed to actuate a valve that controls the flow of feedwater. In this case, a pipe is suspended into the water columns with the bottom end open and at the desired water level. The upper end of the pipe connects, through an orifice of proper size, to an expansion chamber which has two outlets, one communicating pressure within the chamber to either a diaphragm or sylphon operated feed valve, the other being vented to atmosphere. With the water level covering the lower end of the tube, water will pass up and through the orifice into the expansion chamber where, due to the lower pressure, the hot water will flash into steam and increase the pressure causing the valve to close. With a lowering of the water level, only steam will pass through the orifice but due to the vent to

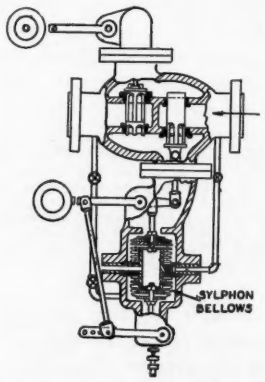


FIG. 5. REGULATOR DESIGNED FOR CONTROL FROM BOTH WATER LEVEL AND STEAM FLOW

atmosphere the steam passes through the expansion chamber without appreciably raising the pressure and the feed valve remains closed.

Need for Control Based on Load

Fluctuating loads, due to any cause whatever, will cause the water level to settle with a cessation of steam generation and swell with an increase. These variations in level may be sufficient under some operating conditions to carry the level out of sight in the gage class. Feedwater regulators basing their action on boiler water level alone cannot meet this condition adequately, since an increase in load should call for an increase in feedwater flow, whereas this sudden load increase raises the water level and closes the feed valve. A sudden decrease in load has the opposite effect on the water level and a sudden increase in feedwater flow takes place with a regulator based on water level alone. The blowing of a safety valve or momentary diminishing of fuel to a pulverized coal burner have been known to set up

dangerous hunting action in the flow of feedwater to boilers having a relatively high ratio of heating surface to water space.

Regulators designed to meet such service not only control the flow from the position of the water line but have additional equipment that feeds water to the boiler, the amount of which varies with the rate at which steam is drawn from the boiler though not in direct proportion. This element is usually a valve actuated by the difference in steam pressure between the inlet and outlet of the superheater, or an orifice may be used to give the necessary pressure differential.

Thus an increase in load will cause a greater pressure drop through the superheater which in turn opens the auxiliary feed valve proportionately though not enough to supply all the feedwater necessary so that as

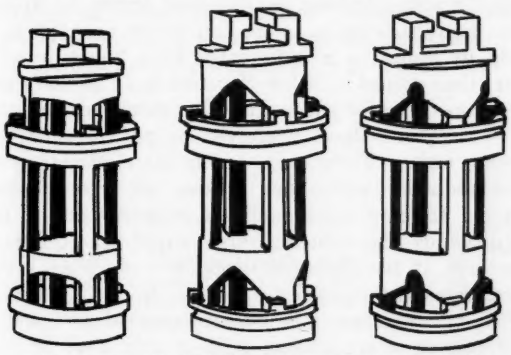


FIG. 6. TYPES OF REGULATOR VALVE PORTS

the load continues the water level will drop and the water line element acts to prevent the water level from going too low. With a sudden decrease in load, the auxiliary valve operated by the steam flow closes but, as the water line drops, the main feed valve opening will be increased. These valves are so designed that an excess amount of water will not be fed when the load is suddenly dropped, and a sudden increase in steam generation, such as takes place when the safety valve blows, with its accompanying swelling of the boiler water and raising of the water level, does not shut off the flow of feedwater but opens the auxiliary valve wide thus tending to stabilize the position of the water line.

Another force used to control feedwater flow in proportion to steam generation is the difference in density of the water in the boiler at different steaming rates. An auxiliary valve which responds to the density of the water in the boiler does not feed when steaming ceases but resumes feeding when steaming is resumed.

Among the refinements in regulator designs which have come with the use of high-pressure boilers are provisions to maintain a pressure in the feed line entering the regulator valve constantly in excess of the boiler pressure by a predetermined amount. Without such provision, an increase in feedwater flow will cause a drop in the feed line pressure, thus calling for a wider opening of the valve than when the excess pressure is constant. Thus without constant excess pressure regulation, the excess pressure is highest at low loads and lowest at high loads, a condition which is undesirable for best operation.

To overcome this difficulty, some regulator valves have been designed with openings of V-notch or modified shapes which will cause the opening to vary at an increasing ratio with the valve lift, thus compensating for the drop in feed line pressure due to the increased flow of water. This design works satisfactorily under certain conditions but the drop in pressure may not be the same at all times for any particular valve opening, notably where several boilers are fed from the same line.

Excess pressure regulators are, therefore, designed

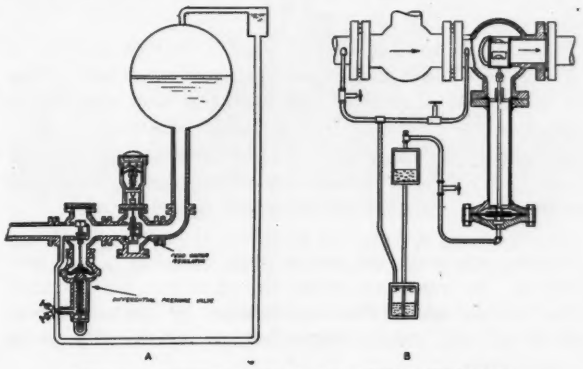


FIG. 7. DIFFERENTIAL PRESSURE VALVES
a. Spring loaded type diaphragm operated valve. b. Differential pressure regulated by mercury column.

to maintain a constant or predetermined pressure on the inlet side of the regulator valve regardless of the amount of valve opening or fluctuating pressure in the feed line. The actuating force for controlling the excess pressure regulating valve, which is placed in the feed line ahead of the feedwater regulator valve, is, in some designs, the difference in pressure between the feedwater line and the boiler modified by the pressure in

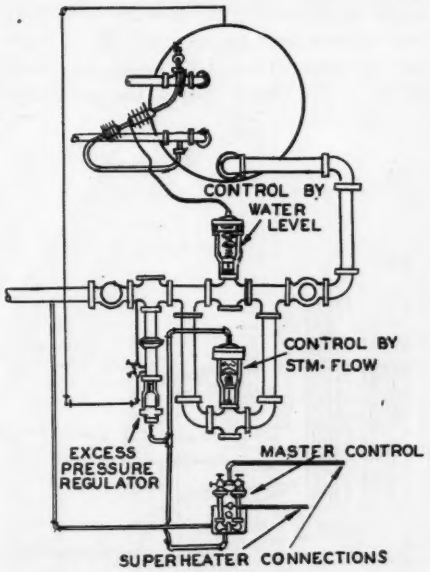


FIG. 8. FEEDWATER CONTROL CONNECTIONS FOR CONTROLLING EXCESS PRESSURE AND FEEDWATER FLOW ACCORDING TO WATER LEVEL AND STEAM FLOW

the generating element that controls the main regulator valve. In another design, the differential pressure is maintained by the action of a mercury column on a diaphragm operated valve. The actuating force in still another design of excess pressure regulator is a combination of the drop in steam pressure across the superheater or an orifice and the differential pressure between the feed line and the boiler, thus varying the differential pressure in proportion to the load.

Meeting the Varied Demands of Paper Mills

BALANCING THE POWER AND STEAM SUPPLY TO A MODERN PAPER MILL CAN BE SOLVED IN A NUMBER OF WAYS BUT IS MADE EASIER IF A TIE-IN WITH ANOTHER COMPANY CAN BE MADE

INDUSTRIAL POWER PLANT DESIGN calls for a close approach to a balanced steam and power system if economical production schedules and keen competition are to be met. When these systems are balanced, there is no steam or heat loss to the atmosphere or to the condenser, the low process steam requirements being just sufficient to generate the electrical power required.

By a wise and careful selection of motor and steam-driven equipment, the power plant problem can be simplified. In some industries, the chemical, for instance, this balance can be further extended by the use of both electrical and steam heaters either individually or in combination.

Briefly stated, the problem is to meet the heat and mechanical power requirements with the minimum amount of steam that is economically feasible. The importance of the last condition should not be overlooked. It is impossible to solve the problem by considering the power plant as an independent unit. Many times the cost of distributing low-pressure exhaust steam more than balances the value of power generated as a by-product or the decrease in capacity of machines when using low-pressure steam may seriously interfere with the output of the plant.

Although no general rule can be laid down, in an old factory the engineer has as much if not more to gain by increasing rather than decreasing the process pressure, looking to the upper end of the cycle, that is, increased boiler pressure for any additional power that he may need to balance the load.

When the steam requisites exceed the electrical requirements, the power problem is relatively simple but when conditions are reversed the problem is more difficult, the relative degree of difficulty depending upon the pressures and temperature at which steam is needed.

By raising the initial pressure sufficiently high and carefully proportioning the different drives, an approximate balance between steam and power usually can be made by going to a sufficiently high boiler pressure. Short time swings in either direction have in many cases been taken care of successfully by steam accumulators.

Other plants have preferred to put in small condensing units. These units are to the electrical system what reducing valves are to the low-pressure steam system. If there is not sufficient exhaust steam to meet the demands, the reducing valves supply the difference. Similarly, if the electrical demands exceed the process steam demand the deficiency is made up by the condensing unit. Whether it is more economical to install an accumulator, a condensing unit of this kind or waste some steam to the atmosphere depends upon the intensity of the load fluctuations.

Perhaps the most popular arrangement at present, due to the generally low power rates, is to install boilers operating at a pressure of from 150 to 400 lb., make just sufficient steam to meet the process requirements, gen-

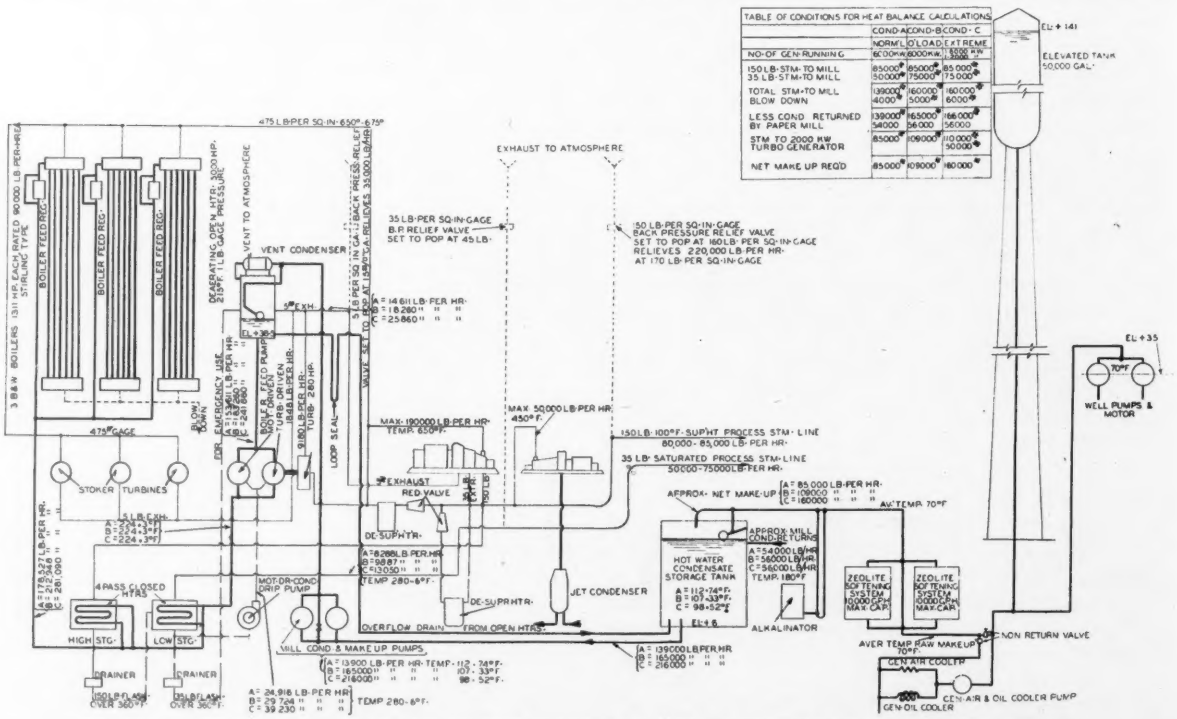


TABLE OF CONDITIONS FOR HEAT BALANCE CALCULATIONS
COND-A
COND-B
COND-C
NORMAL
LOAD
EXTREME
NO-OF GEN-RUNNING
150 LB-STM-TO MILL
35 LB-STM-TO MILL
TOTAL STM-TO MILL
BLOW DOWN
LESS COND. RETURNED BY PAPER MILL
STM TO 2000 KW TURBO GENERATOR
NET MAKE UP REQD
EL+141
ELEVATED TANK 50,000 GAL.
EXHAUST TO ATMOSPHERE
35 LB-PER SQ-IN-GAGE B.P. RELIEF VALVE SET TO POP AT 45 LB.
50 LB-PER SQ-IN-GAGE BACK PRESSURE RELIEF VALVE SET TO POP AT 160 LB. PER SQ-IN-GAGE RELIEVES 220,000 LB. PER HR. AT 170 LB. PER SQ-IN-GAGE
VENT CONDENSER
VENT TO ATMOSPHERE
BOILER FEED REG.
475 LB. PER SQ-IN-650°-675°
475# GAGE
STOKER
TURBINES
EXHAUST RED. VALVE
MAX. 50,000 LB. PER HR. 450°F.
MAX. 180000 LB. PER HR. TEMP. 650°F.
150 LB. 100°F. SUPHT. PROCESS STM. LINE 80,000-85,000 LB. PER HR.
35 LB. SATURATED PROCESS STM. LINE 50000-75000 LB. PER HR.
DE-SUPHTR.
4 PASS CLOSED HTRS.
HIGH STG.
LOW STG.
DRAINER
MOT. DR. COND. DRIP PUMP
MILL COND. & MAKE UP PUMPS
OVERFLOW DRAIN FROM OPEN HTRS.
JET CONDENSER
HOT WATER CONDENSATE STORAGE TANK
APPROX. MILL COND. RETURN
APPROX. NET MAKE-UP
AV. TEMP. 70°F
ALKALINATOR
ZEOLITE SOFTENING SYSTEM 100,000 GPG MAX. CAP.
ZEOLITE SOFTENING SYSTEM 60,000 GPG MAX. CAP.
AVER. TEMP. RAW MAKE UP 70°F.
NON RETURN VALVE
GEN. AIR COOLER
GEN. OIL COOLER
GEN. AIR & OIL COOLER PUMP
EL+35
70°F
WELL PUMPS & MOTOR

FIG. 1. HEAT BALANCE DIAGRAM OF THE SOUTHEASTERN PRODUCTION CO. PLANT AT MOBILE

erate as much power as possible from the steam in back pressure turbines and purchase the remainder.

A combination of both methods is used in the new 8000-kw. plant of the Southeastern Production Co. at Mobile. Steam at three pressures is furnished by a 6000-kw. unit receiving steam at 450 lb. bleeding at 150 and 35 lb. and exhausting at 5 lb. gage. A second 2000-kw., 150-lb. condensing unit is installed for emergencies and standby and the plant is tied in electrically with the Alabama Power Co. system.

Extracted steam is used in a paper mill, at 150 lb. not exceeding 100 deg. superheat, for digesters and in steam turbines driving the Fourdriniers and at 35 lb. for drying and other process requirements.

As can be seen from the heat balance diagram, some of this extracted steam is also used for feedwater heating. Exhaust steam at 5 lb. gage goes to the open feedwater and deaerating heater. Normally the steam flow to the turbine is controlled by the pressures in the three systems but in emergencies the speed governor can be cut in allowing the machine to carry the full 6000-kw. load, steam in excess of the process and feedwater de-

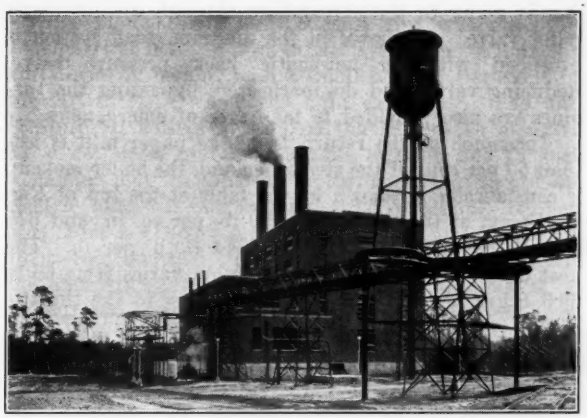
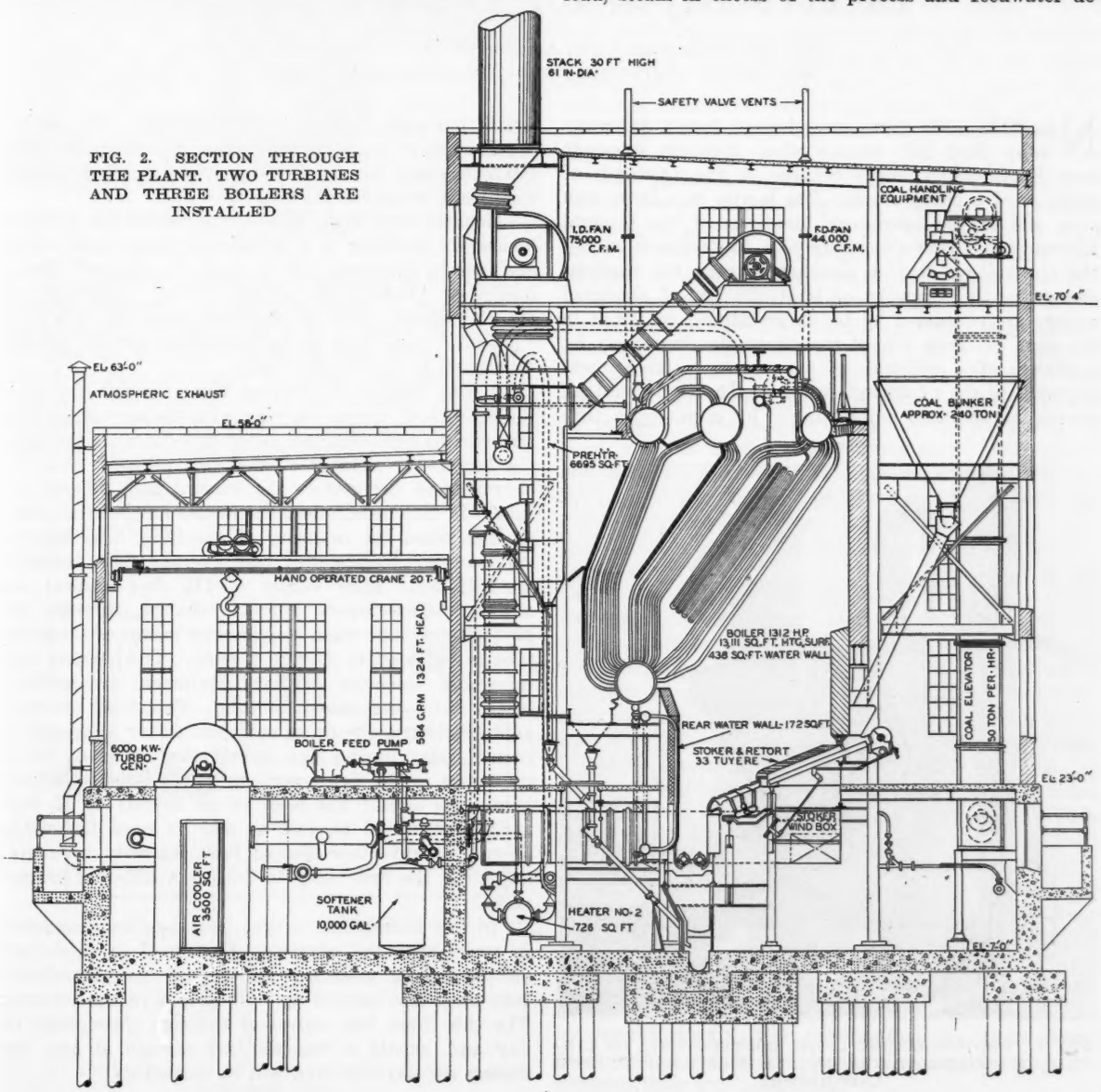


FIG. 3. AN EXTERIOR VIEW OF THE PLANT SHOWING BOTH ELECTRIC AND STEAM TRANSMISSION LINES

FIG. 2. SECTION THROUGH THE PLANT. TWO TURBINES AND THREE BOILERS ARE INSTALLED


STACK 30 FT HIGH 61 IN. DIA.
SAFETY VALVE VENTS
COAL HANDLING EQUIPMENT
I.D. FAN 75,000 C.F.M.
F.D. FAN 44,000 C.F.M.
EL. 70' 4"
EL. 63'-0"
ATMOSPHERIC EXHAUST
EL. 58'-0"
COAL BUNKER APPROX. 240 TONS
PREHTR. 6695 SQ. FT.
HAND OPERATED CRANE 20 T.
BOILER 1312 H.P. 13,111 SQ. FT. HTG. SURF. 438 SQ. FT. WATER WALL
584 G.P.M. 1324 FT. HEAD
6000 KW. TURBO-GEN.
BOILER FEED PUMP
REAR WATER WALL 172 SQ. FT.
COAL ELEVATOR 50 TON PER HR.
STOKER & RETORT 33 TUYERE
EL. 23'-0"
STOKER WIND BOX
AIR COOLER 3500 SQ. FT.
SOFTENER TANK 10,000 GAL.
HEATER NO. 2 726 SQ. FT.
EL. 7'-0"

mands going to the atmosphere through an automatic relief valve. As shown in the diagram, each system is equipped with an automatic back pressure valve. Reducing valves and desuperheaters bypassing the turbines are also provided to take care of emergencies.

Inasmuch as the return from the paper mill is less than 50 per cent of the steam demand, the boiler makeup is considerable as shown by the table at the top of Fig. 1. Steam at the throttle at 450 lb. per sq. in. and 675 deg. F. has a heat content of 1344 B.t.u. per lb. The heat drop in the high-pressure section varies from 68 to 69.6 B.t.u. per lb. at a total steam flow to the throttle of 100,000 to 190,000 lb. of steam per hour. In the intermediate section, the heat drop varies from 71.4 to 79.7 B.t.u. per lb. with flow of 50,000 to 80,000 lb. per hr. through this section and falls off to 78 B.t.u. per lb. at a flow of 90,000 lb. per hr.

In the low-pressure section, the heat drop varies from 25.5 B.t.u. per lb. at 5000 lb. per hr. to a maximum of 49.8 B.t.u. per hr. at 17,500 lb. per hr and falls off slightly to 492 B.t.u. at 20,000 lb. per hr. flow. Power calculation must treat each section separately as the flow through any sections may vary independently of the flow through the other two.

Steam is supplied by three 13,111-sq. ft. boilers, rated 90,000 lb. per hr. maximum and 60,000 lb. per hr. normal, fired by underfeed stokers. Superheaters and air heaters are provided and each boiler is served by one 44,000-c.f.m. (15-in. W.G.) forced draft and one 75,000-c.f.m. (6-in. W.G.) induced draft fan both located above the boiler. Under usual operating condition, three boilers will be operated but two can carry the load if necessary.

Electric Eyes for Electric Signs

DETAILS OF CONTROL UNIT, APPLIED TO SIGNS AND OTHER EQUIPMENT, EMPLOYING THE PHOTOELECTRIC TUBE

NEARLY 1500 25-w. incandescent lamps automatically flash into service when darkness descends over Schenectady, either because of the approach of night or of a heavy storm. The lamps, in a large sign atop one of the laboratory buildings of the General Electric Co., follow the whims of a photoelectric tube—the electric eye that is sensitive to even the slightest change in the intensity of light; 36 kw. of electrical energy are consumed by the large number of lamps in the sign, yet they are all turned on simultaneously by a change of a millionth of an ampere in the current supplied to the photoelectric tube. The sign could, of course, be operated automatically by means of a time switch but such a switch lacks flexibility. The switch operates at a predetermined time, whatever the light conditions may be; the tube operates according to light conditions, whatever the time may be.

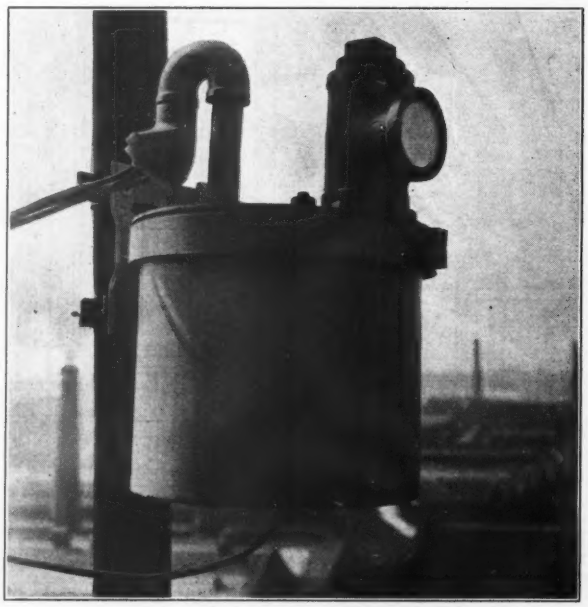


FIG. 1. PHOTOELECTRIC LIGHT CONTROL UNIT ON CIRCUIT OF FLOODLIGHTS AS INSTALLED ON G.E. RESEARCH LABORATORY

Mounted on a small pole on the roof of the six-story laboratory building is a cylindrical metal tank, about one foot in diameter, with a small "periscope" facing northwest. Behind the window of the "periscope" is the photoelectric tube, of about the same size as a radio "peanut" tube, with its light-sensitive surface pointed into space to receive sky light.

A tiny amount of current flows through the tube, the amount of current varying with the amount of light striking the light-sensitive electrode—the more the light, the larger the number of electrons released from the elctrode and the greater the current flow through the tube. In this installation, the device has been adjusted so that when the intensity of the light falls below a value of ten foot-candles (the average light intensity one-half hour after sunset is 1½ foot-candles) the millionth-of-an-ampere current change through the photoelectric tube when amplified by means of a vacuum tube is sufficient to operate a relay. The vacuum tube relay and necessary auxiliary equipment are mounted in the metal case below the tube. This relay energizes another electric circuit, of sufficient power to operate in turn a relay in the sign circuit that turns on or off the lamps in the sign according to the light conditions. While the circuit has been set to operate at 10 foot-candles, it would be just as easy to have the circuit operate at any other desired light intensity by simply adjusting the first relay to trip at a different current value.

In this installation, a time clock has been connected in series with the photoelectric control so as to turn off the sign at midnight, and to put the photoelectric tube back into control at 7:30 o'clock in the morning. The tube then has control of the sign throughout the day and, should it become dark enough at any time during the day, the sign will be turned on.

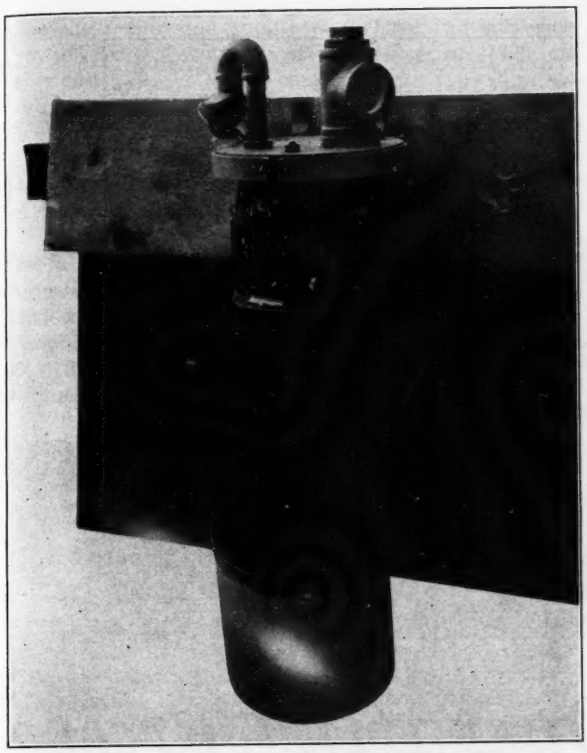


FIG. 2. PHOTOELECTRIC LIGHT CONTROL UNIT WITH COVER REMOVED

In connection with the investigations of the General Electric engineers, a recording meter is connected to the photoelectric control so that a record is made of the time the contacts are closed and opened. As the days have been increasing in length, the time has been later and later according to the weather conditions. On days when the sky has been clear, the starting time has been later than on cloudy days.

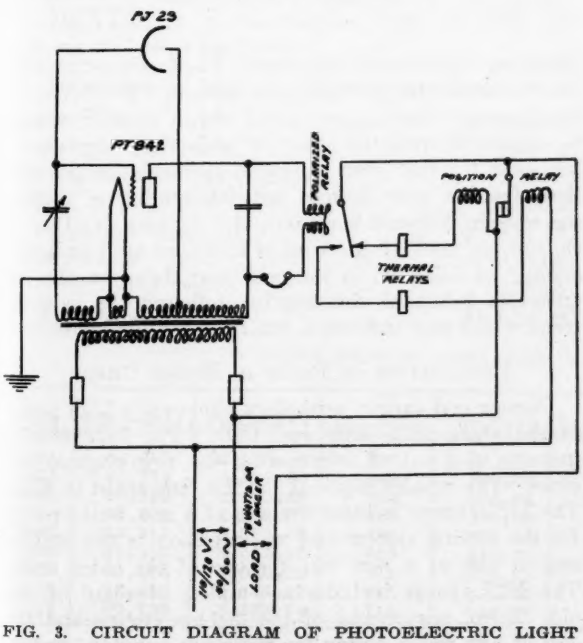


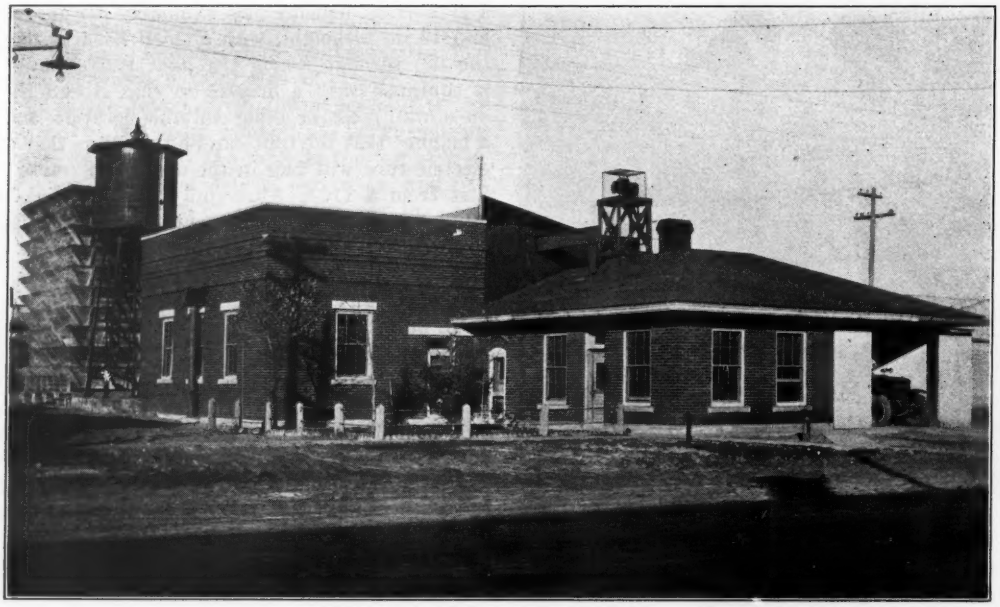
FIG. 3. CIRCUIT DIAGRAM OF PHOTOELECTRIC LIGHT CONTROL UNIT

The photoelectric light control unit is mounted in a cylindrical housing approximately 8½ in. in diameter and 12 in. in height, with a small hood or periscope on the top through which the light can enter. The unit is equipped with a bracket so that it can be mounted on a wall, post or other suitable location and in such a manner that the unit can be turned so that the photoelectric tube will face in the desired direction. It operates from a 110-v. a.c. supply and consumes less than 10 w. continuously. The contacts on the relays within the unit will control a load of approximately 500 w. at 110 v.; additional relays and switches can be employed to control any amount of energy desired, just as was done in the case of the sign control. The unit may be set to operate at any light intensity between 2 and 20 foot-candles. The accuracy of the unit is such that it is sensitive to variations from any setting within one or two foot-candles. When the daylight intensity drops to such a point that it is below the setting of the unit, it will operate and remain in operation until this light intensity increases to a value above the setting. With such flexibility of operation, the device may be installed in locations where the intensity of available light varies considerably. The operation of the unit under these different conditions will be such that it will not function with variations of less than one or two foot-candles intensity.

This photoelectric light control unit can be applied to the control of street lighting circuits. At present, such lights are turned on or off according to a fixed schedule which does not always conform to daylight conditions. If the lights could be turned on when the daylight drops to a point where the light is not sufficient for safety and could be turned off when the daylight increases to a point where artificial light is not required, then more satisfactory lighting could be obtained. The unit can also be applied to interior lighting, such as in schools, factories and offices; to the operation of floodlights and store window illumination. With slight modifications, the same equipment is also applicable for such work as vehicle or pedestrian counting, and the operation of traffic signals.

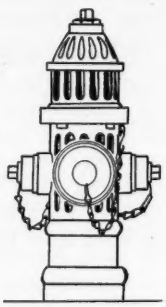
IN THE Ford Industrial Museum at Detroit is the first Heine water tube boiler which ran in the First Regiment Armory at St. Louis from 1882 until the armory burned in 1917. The boiler was salvaged and placed on exhibit at the Heine shop. This boiler, had it operated 24 hr. a day, 365 days a year for the 48 yr. since it was built, could have made only as much steam as one of the new boilers in Hell Gate Station, operating at its maximum capacity of 1,250,000 lb. of steam an hour would make in 11 days, although each represents the best practice at the time it was built. This gives a sharp picture of the advance in standards over the half-century period.

TOTAL APPARENT consumption of babbit metal in February, based on reports received by the Department of Commerce from 31 firms, was 3,726,576 lb., as compared with 4,408,455 in January and 5,720,243 in February, 1929. This consumption is calculated from sales by manufacturers and consumption by those firms (among them several important railroad systems) which consume their own production.



Nine-Year Operating Record of Diesel Plant

CARE IN KEEPING COMPLETE RECORDS AND IN ANALYZING THE OPERATING COSTS AIDS MATERIALLY IN REDUCING THE COSTS OF MAINTENANCE AND OPERATION AT THE DIESEL ENGINE PLANT OF LA CROSSE, KANSAS



GOOD MANAGEMENT as well as proper equipment is exemplified in the Diesel power plant of the La Crosse, Kansas, Light and Water Department. Careful performance and maintenance cost records, kept by the City Manager, Jess C. Moser, for the past 8 yr., show what may be done in reducing power and maintenance costs by the exercise of proper and timely attention.

In the original installation, made in 1916, there were two small De La Vergne Diesel engines, one being a 60-hp. horizontal and the other a 120-hp. vertical engine. In 1922 a 260-hp. vertical 4-cycle, solid injection De La Vergne Diesel was added and in 1928 the 60-hp. engine was replaced by a 330-hp. vertical 4-cycle, solid injection De La Vergne Diesel engine as the load had increased to a point where a 60-hp. engine was no longer of value. The total capacity of the plant now is 710 hp.

CHART AIDS IN ANALYZING OPERATION COSTS

Costs covering the years 1921 to 1929 inclusive are shown in the table. The fuel cost includes fuel oil used for station and office heating; 1500 gal. were used for this purpose during 1929. The chart, Fig. 2, is an illustration of how any power plant engineer can analyze the operating conditions of his plant. The fuel consumption follows closely the kilowatt-hour output. The break in the lubricant consumption trend shown at 1928 cannot be explained from the chart or table since the cost of lubricant for that year, shown in the table, is also less than for the year before, notwithstanding a normal increase in kilowatt-hour output. It may be that a change was made in the kind of lubricant used or in the manner of using it; in the next year, however, the increase in lubricant consumption followed the original trend which may indicate a return to former conditions.

EXPLANATION OF PEAKS IN REPAIR CHART

Repair and supply costs show abnormally high peaks in the years 1922, 1923 and 1927. The 1922 charge includes the cost of overhauling the two original engines. The repairs required for this, amounted to $215. The 1923 charge includes the cost of a new water pump for the cooling system and an extension to the cooling system also of a new belt for one of the older units. The 1927 charge includes a complete overhaul of the old 120-hp. engine and of the 260-hp. engine and the cost of new water piping for these two engines. Other-

wise the repair and supply costs have run extremely low. With the exception of the charge for 1925, the labor cost has been almost constant, notwithstanding the additional units which were installed. This illustrates an advantage gained by larger capacity even where the individual units are comparatively small in size. The high peak in 1925, the cause of which is not known to us, was corrected the later years.

Total operating costs increased slightly but not in as fast a rate as increase in kilowatt-hour output. The maximum operating cost per kilowatt-hour occurred in 1922 when the amount was 1.63 cents. This cost was consistently reduced through the years to a low record of 1.03 cents in 1929. These costs from 1921 to 1929 were as follows: 1.5, 1.6, 1.3, 1.2, 1.3, 1.3, 1.3, 1.1 and 1.0

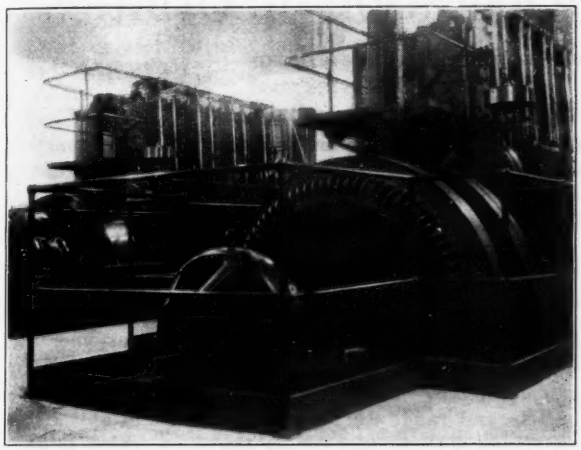


FIG. 1. DE LA VERGNE DIESEL ENGINES CARRY THE LOAD

cents per kw-hr. They do not include overhead charges of any kind. The changes in the total yearly receipts indicate lowering of charge rates. The receipts per kilowatt-hour ranged from a high rate in 1921 of 5.33 cents to a low rate of 3.25 cents in 1927. In 1929, this rate was 3.53 cents per kw-hr.

SUMMARY OF NINE YEARS OPERATING RECORD

Fuel oil cost	$ 24,689.99
Lubricating oil cost	2,642.43
Repairs, stock and supplies	2,425.85
Labor	33,305.60
Operating Cost	$ 63,063.87
Total revenue	$189,311.82
Total operating cost	63,063.87
Gross profit for 9 yr	$126,247.95

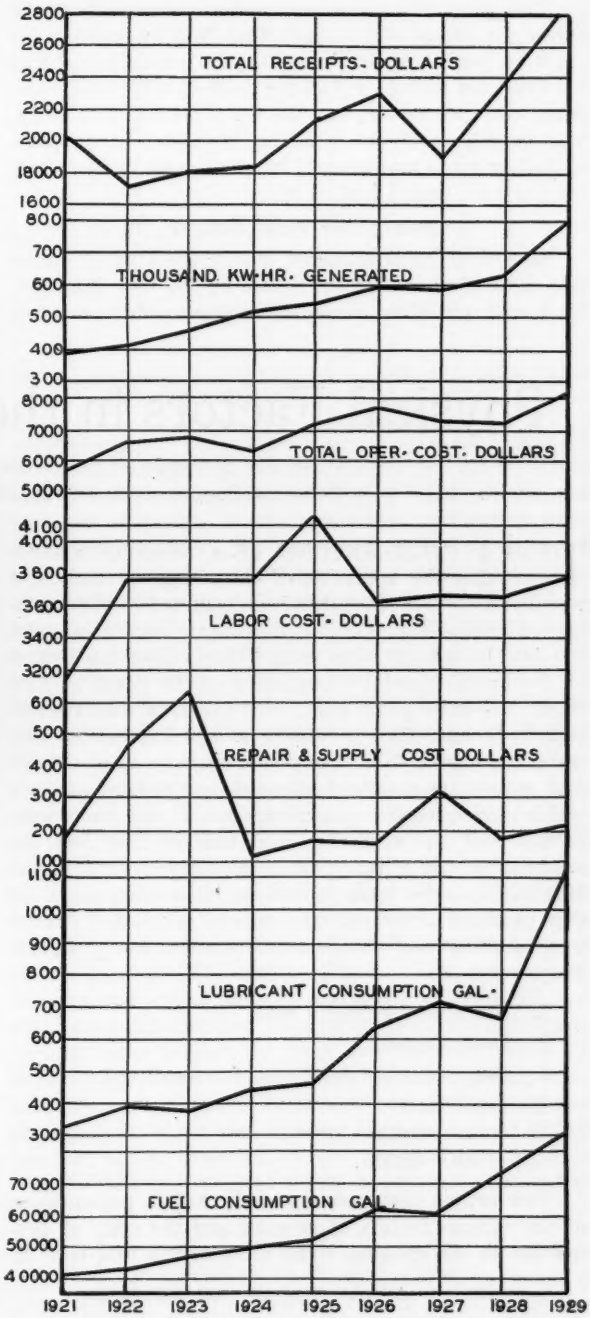


FIG. 2. CHART SHOWING RELATION OF OPERATING COSTS

TABLE SHOWING OPERATING COSTS FOR THE NINE-YEAR PERIOD

Year	Fuel-Gals.	Fuel-Cost	Lub.Gals.	Lub.Cost	Rep.& Sup.	Labor	Total Op.Cost	K.W.H. Gen.	Total Receipts
1921	42,495	$2,280.18	327	$ 151.91	$ 179.20	$3,129.60	$5,740.89	381,548	$20,344.40
1922	43,779	2,199.90	388	189.00	465.34	3,780.00	6,634.24	407,568	17,124.25
1923	46,760	2,315.68	374	136.54	636.59	3,780.00	6,768.81	457,887	18,028.31
1924	49,452	2,264.07	447	198.40	120.73	3,780.00	6,363.20	515,453	18,367.24
1925	58,917	2,565.43	460	275.42	166.59	4,170.00	7,177.44	536,106	21,277.93
1926	61,815	3,663.75	639	290.06	150.62	3,630.00	7,734.43	589,890	23,058.23
1927	60,174	3,045.15	715	334.53	315.87	3,656.00	7,351.55	583,141	18,941.60
1928	72,528	3,076.89	665	322.23	174.44	3,600.00	7,172.56	629,936	23,451.08
1929	80,733	3,378.94	1115	744.34	216.47	3,780.00	8,118.75	791,568	28,718.78
TOTAL	510,653	$24,689.99	5130	$2,642.43	$2,425.85	$33,305.60	$63,063.87	4,893,097	$189,311.82

This gives the following average values: Kilowatt-hours per gallon of fuel including fuel for heating for the 9-yr. period, 9.58; kilowatt-hours per gallon of fuel for 1929, not including fuel for heating, 9.99; total operating cost per kw-hr. for the 9-yr. period, 1.29 cents. The average cost per year for repairs and supplies, including waste and general supplies used in the plant, for the 9-yr. period is $269.50.

Reliability Demonstrated

No serious break occurred during the 9 yr. of operation, according to a recent report by the City Manager. No forced shut-down caused by engine trouble was experienced at any time during the past 6 yr. It has not been found necessary to take an engine off the line due to engine trouble during this period. The only work done on the two vertical engines has been to regrind the valves which has been done only twice during the past 2 yr.

No trouble with fuel valves or fuel pumps has developed. The fuel injection valves on the vertical engines, which are made of stainless steel, have not been changed or cleaned during the past 2 yr. The original cylinder heads are still in place and in service. No cylinder head failure due to any cause has occurred.

Physical Factors in the Operation of Utilities

Part II. A Study of the Various Factors of Revenue and the Costs of Production in Stations. By Robert T. Livingston*

THIS IS THE SECOND of a series of articles analyzing the operation of electric power and light companies.[1] This study has been confined to the operations of those companies within New York State and the data have been taken from Volume II of the Report of the Public Service Commission of the State of New York. The three years 1917, 1922 and 1927 were studied separately and also in respect to one another so that the changes over the 10-yr. period could be seen. In the first article, the standard statistical methods of analysis which were used were explained and all the terms were defined and the methods were illustrated as was the meaning of the terms. The reader is referred to the March 1 issue for these definitions and explanations. In this previous article certain general operating factors were studied and their variation was clearly shown. They were

1. Per cent Electricity sold
2. Load Factor
3. Per cent Electricity sold for lighting
4. Use Factor
   (a) steam
   (b) hydro.

This article continues the study with a presentation of the various factors of revenue and the costs of production in the stations. The third article will take up the costs of delivering the electricity to the customer and the general costs of administration and management.

Before taking up a study of costs, it is necessary to analyze the revenue to determine how it varies and with what, for while costs are important and the reduction of them vital, it is in the sales end that the money is made and as all utilities are run primarily to make a return upon the money invested, a study of the revenue is of primary importance.

TABLE I. AVERAGE LOAD PER CUSTOMER

Year	No. of Cases	Mode	Range	Median
1917	86	0.141	0.05 - 0.25	0.237
1922	51	0.170	0.05 - 0.25	0.233
1927	60	0.145	0.05 - 0.35	0.287
All	197	0.144	0.05 - 0.25	0.250

Kilowatts Load Per Customer

Tables I and II are a study of the average load per customer. In the first case the load per customer was determined for each year and for all three years together, and by standard statistical methods the mode, median and range were determined. There appears to have been a slight increase in this item which is indicated quite clearly by the median, even though neither the mode nor the range shows it. The variation of the average load per customer with the percentage sale of electricity for lighting is shown in Table II. As before, each year is analyzed separately and then all are combined. It is seen that as the lighting sales increase—and hence the power sales decrease—that the average load decreases. In the higher percentages the year 1927 shows an increase over 1917, as is the claim of the public utility executives but in the lower percentages the reverse is true. This is reasonable if one considers that there are an increasing number of relatively small power users who in early days perhaps had their own stations but as the boilers and engines became obsolete, purchased electricity from the power companies rather than rebuild their stations or continue to use their expensive equipment. The addition of a large number of relatively small users as well as these replacement jobs have tended to bring this ratio down.

TABLE II. VARIATION OF AVERAGE LOAD PER CUSTOMER VS. PER CENT LIGHTING LOAD

Year	0-10	10-20	20-30	30-40	40-50	50-60	60+
1917	1.280	0.444	0.258	0.187	0.117	0.113	0.068
1922	0.376	0.367	0.268	0.188	0.141	0.068	0.068
1927	0.957	0.418	0.279	0.250	0.146	0.110	0.104
All	0.671	0.410	0.268	0.208	0.138	0.097	0.086

Tables III and IV present a similar analysis of the peak load. In this case, there was a very wide variation of values and it was difficult to arrive at any satisfac-

*Assistant Professor Mechanical Engineering, Columbia University.

[1]The first appeared on page 286, Mar. 1 issue.

TABLE III. PEAK LOAD PER CUSTOMER

Year	No. of Cases	Mode	Range	Median
1917	68	0.467	0.2 - 0.6	0.675
1922	47	0.500	0.2 - 0.6	0.750
1927	38	0.550	0.2 - 0.6	0.600
All	153	0.583	0.2 - 0.6	0.830

TABLE IV. PEAK LOAD PER CUSTOMER VS. PER CENT LIGHTING SALES

Year	0-10	10-20	20-30	30-40	40-50	50+
1917	1.92	1.14	0.59	0.63	0.43	0.35
1922	1.06	1.02	0.75	0.55	0.51	0.29
1927	1.33	0.80	0.64	0.64	0.35	0.23
All	1.44	0.99	0.66	0.61	0.43	0.29

tory conclusions. The range shows no change, the mode shows a substantial increase while the median shows an equally substantial decrease. Other studies tend to show that the peak per customer is not materially changing and certainly not as much as the average load per customer; however, from the data here presented no definite conclusions can be drawn but from Table IV, which shows the variation of the peak load with the percentage of lighting business, it is seen that except for the two lowest groups there has been no substantial change in the peak load per customer. The same explanation holds for the decrease of peak load per customer in the lowest groups as for the average load. The decrease indicated in the highest group may be due to the fact that most of the new residential or lighting customers now being taken on by the utilities are of the class known as "convenience users" who use so little electricity that it is doubtful whether it pays to serve them and whose peak and average requirements are small. Figure 1 presents these same data graphically. It is interesting to compare the ratio of these two curves—which would be the load factor—with the curve for load factor previously submitted. In the two cases, the results are in substantial agreement.

The next thing of interest is to know the dollars of

TABLE V. DOLLARS REVENUE PER CUSTOMER

Year	No. of Cases	Mode	Range	Median
1917	83	53	30 - 70	59
1922	59	72	50 - 90	72
1927	57	70	50 - 90	73
All	199	70	50 - 90	70

TABLE VI. DOLLARS REVENUE PER CUSTOMER VS. PER CENT LIGHTING SALES

Year	0-10	10-20	20-30	30-40	40-50	over 50
1917	$100	$ 90	$68	$55	$50	$40
1922	100	100	85	70	65	50
1927	100	80	70	65	60	50
All	100	85	75	65	60	50

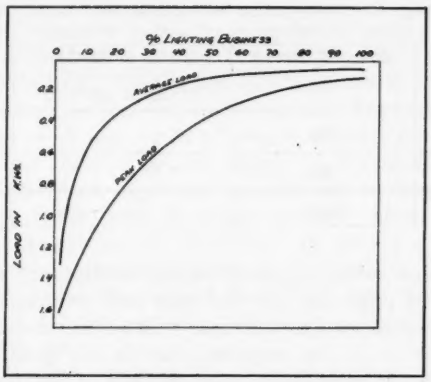


FIG. 1. VARIATION OF PEAK LOAD AND AVERAGE WITH THE PER CENT OF LIGHTING BUSINESS

revenue secured per customer served. Tables V and VI present an analysis of this in a similar manner as before and it is shown graphically in Fig. 2. The revenue per customer decreases as the percentage of lighting sales increases but there has been a very real increase of revenue per customer of the ten-year period. In the curve, two limits are given a "lower reasonable limit" and an upper limit of expectation. Unless there is something unusual about the particular company being analyzed, it will fall between these two curves; if near the lower curve, there is certain to be much room for improvement and active effort of the commercial department can raise it up.

As there is a relationship between peak per customer and the percentage lighting sales and also a relation between revenue per customer and the lighting sales, there must also be a relationship between the revenue per kw. peak and the lighting sales. This is an interesting factor and is particularly interesting when analyzing an unknown company. This relationship is shown in Table VII and in Fig. 3. The data is very wide spread and a straight statistical analysis did not yield much information. The curves, presented as before with a lower reasonable limit and an upper limit of expectation, are very interesting. As the lighting business increases, the revenue on each kw. of peak increases and while at 15 per cent lighting rates only about $82.00 per kw. can be expected, at 100 per cent lighting load over $200.00 per kw. peak would be obtained. A similar

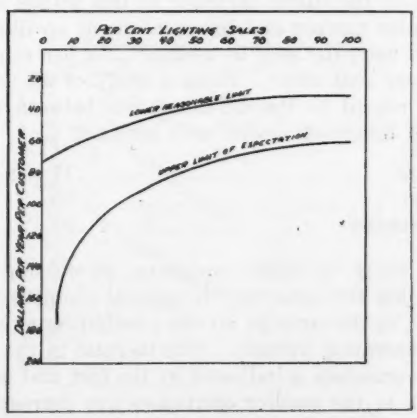

Per Cent Lighting Sales
0 10 20 30 40 50 60 70 80 90 100
Lower Reasonable Limit
Upper Limit of Expectation
Dollars Per Year Per Customer

FIG. 2. REVENUE PER CUSTOMER COMPARED TO PER CENT LIGHTING SALES

TABLE VII. DOLLARS REVENUE PER KW. PEAK

Year	No. of Cases	Mode Range	Median
1917	73	complete spread	80
1922	54	" "	85
1927	38	" "	125
All	165	" "	95

conclusion could be obtained by multiplying the two curves of peak load per customer and revenue per customer together. This increase with an increase of lighting load is to be expected due to the greater unit revenue. It is probable that the lack of diversity of a lighting load tends to bend the curves over in their higher ranges.

Production Costs and Ratios

Operating ratio may be here defined as the ratio between the total station expenses and the operating revenue. In Fig. 4 the operating ratio is plotted against the per cent electricity supplied by steam, hydro or bought. As this is a new form of curve, it is well to explain its use. There are two pairs of curves, one pair for hydro companies and one pair for steam companies. Each pair consists of an upper and a lower limit. These curves were obtained by plotting each ratio against the per cent electricity generated by steam or by hydro. For example, if a company had an operating ratio of 30 and 40 per cent of its energy were produced by a steam plant and 60 per cent by a hydro plant, that 30 per cent would be plotted against both 40 and 60, forty for the steam curve and 60 for the hydro curve as indicated on Fig. 4. The method of using this curve is to determine what operating ratio to expect with any company if the percentage electricity produced by steam and hydro is known. As an example, if a company is assumed which generates 75 per cent of its electricity by water power and 25 per cent of its electricity by steam power, then for the 75 per cent hydro the ratio should be between 11 and 33 per cent, and for the 25 per cent steam the ratio should be between 20 and 60 per cent. The ratio cannot be less than the 20 per cent imposed by the steam station nor higher than the 33 per cent imposed by the hydro station; therefore, it must be between 20 and 33, or about 26 per cent as an estimate. The rest of the curves included in this article are used in a similar manner and for each one as an illustration the same company will be assumed; 75 per cent hydro and 25 per cent steam. From a study of all the ratios without regard to the differentiation between percentages, the following modes were obtained

Hydro	11 per cent
Steam	35 " "
Purchasing	29 " "

The study of those companies purchasing energy showed that the costs were in general competitive; that is to say, as the costs go up the possibilities of steam or hydro generation increase. The increase in the amount of interconnection is indicated by the fact that generally the costs to the smaller companies are decreasing and that many companies which in 1917 generated the major part of their electricity by small and inefficient steam

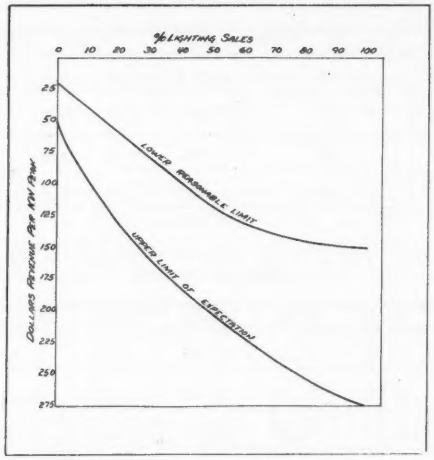


FIG. 3. REVENUE PER KW. PEAK WITH PER CENT LIGHTING SALES

stations, in 1927 purchased the larger part of their requirements.

The unit costs in cents per kw-hr. are presented in Fig. 5 in a similar manner to the operating ratio. In this case the range or spread is very large and conclusions are hard to reach. In the best company the limits are: by hydro 0.13 to 0.82 and by steam from 0.43 to 2.1. Therefore, it is to be expected that the costs will run between 0.43 and 0.82 or about 0.6c. kw-hr. A tabulation of the modes gives

Hydro	0.12c kw-hr.	
Steam	1.32 kw-hr.	
Purchasing	1.10 kw-hr.	ranges up to 3c kw-hr.

While the unit cost varies a great deal, it is to be expected that the costs based on dollars per year per kw. peak will not show any greater or as great variation and this study is presented in Fig. 6. As the per cent hydro generation increases the costs decrease. In the case of steam, an interesting condition is presented by the shape of the upper limit curve. From the mid point, this increases both as the per cent steam generation increases. The increase of cost with increase of percentage is understandable. As a system generates more and more of its electricity and buys less and less, the purchasing becomes nothing more than service insur-

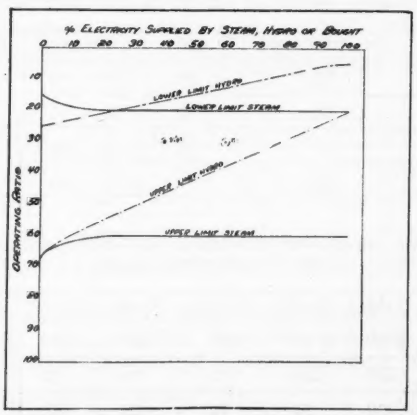


FIG. 4. OPERATING RATIO PLOTTED AGAINST THE PERCENTAGE OF ELECTRICITY SUPPLIED BY STEAM OR HYDRO OR BOUGHT

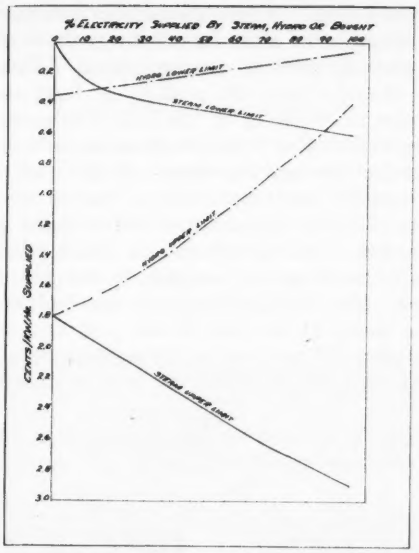


FIG. 5. UNIT COSTS COMPARED TO ELECTRICITY SUPPLIED BY STEAM, HYDRO OR PURCHASED

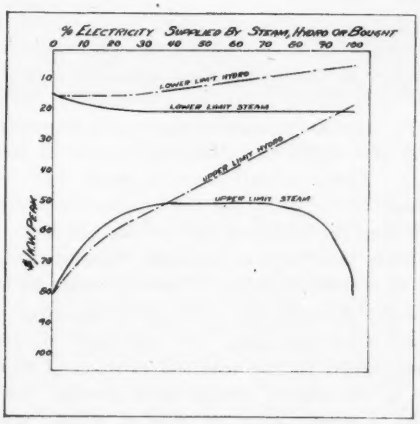


FIG. 6. DOLLARS PER KW. PEAK COMPARED TO THE ELECTRICITY SUPPLIED

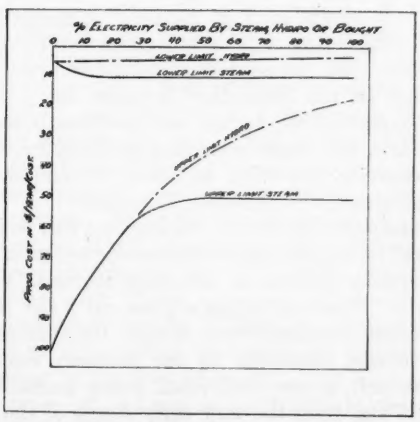


FIG. 7. PRODUCTION COSTS IN TERMS OF ELECTRICITY SUPPLIED

ance and whatever is bought is probably bought on the peak and the load is of very little value to the company which is selling. This is not shown in the hydro company because hydro companies generally have an excess of power at certain times of year and usually have arranged for interchange of energy at reasonable rates and being both a buyer and a seller can arrange more favorable terms than the steam company which has to burn coal to produce its electricity. In the lower region, it becomes a competitive problem, the utility has not sufficient steam capacity to supply its own load, consequently it must pay any reasonable price which the seller may ask.

For the best company the hydro generation gives the limits from $8.00—$31.00 and the steam generation from $20.00—$52.00. Therefore the cost for this company under consideration will probably be in the nature of $25.00 per kw. peak. The summary of the modes gives

Hydro	$15.00
Steam	40.00

Those companies purchasing energy are not presented because sufficient data is not given in the reports of the New York State Public Service Commission.

As the revenues are analyzed in terms of dollars per customer per year, it is interesting to analyze the production costs in the same units. This is done in Fig. 7. For both hydro and steam generation, the lower limits are very flat but in the lower percentages, the upper limits rise extremely high with a probable upper limit of about $100.00. At 30 per cent the two upper limit curves merge. For the company with 75 per cent hydro generation and 25 per cent steam generation, the limits obtained are: hydro from $4.00—$24.00 and for steam from $10.00—$60.00. The best company will therefore fall between $10.00, the lower limit of steam and $24.00 the upper limit of hydro or about $17.00 per customer per year. The modes are

Steam	$24.00
Hydro	13.50
Purchasing	17.50

In every case, it is to be assumed that the upper limits of these curves are governed by the cost of the electricity purchased and that generally the cost of

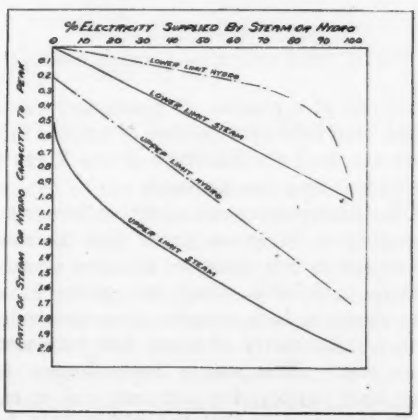


FIG. 8. STEAM OR HYDRO CAPACITY TO PEAK COMPARED TO ELECTRICITY SUPPLIED

purchased electricity will be higher than the cost of produced electricity. Nevertheless those companies which purchase all their energy in every one of these cases shown, show a lower mode than the steam companies. This fallacy is only apparent. In the case where a company purchases all of its energy, the question is purely competitive; that is to say, if too high a rate is charged the company can always build its own station and produce its own electricity. When only a fraction of the energy is purchased, however, the energy purchased will usually cost more than if all is bought. As previously explained, this is reasonable because the purchase is a convenience or service insurance or during a period when the company has insufficient capacity to carry its own load and has not yet built a new plant, and, therefore, is buying power to carry its peak.

One other ratio of interest is the relationship between capacity and peak. Where a company generates all its energy, its capacity must exceed its peak to allow for growth and accident to the equipment. Usually the capacity should exceed the peak by at least one year's growth plus the capacity of the largest generating unit on the system. For hydro companies the capacity is generally 25 per cent in excess of the peak and for steam about 50 per cent. This is due to the greater reliability of hydro companies as well as to the generally slower growth. This is indicated in Fig. 8, which shows graphically in a similar manner to the other curves presented. For the best company the hydro capacity would be about 80 per cent of the peak and the steam capacity about 60 per cent of the peak so that the combined capacity would exceed the peak by about 40 per cent.

The next article continuing the analysis of the costs will be presented in an early issue.

Electricity---What It Is and How It Acts*

PART XXXIX. THE SIGNIFICANCE OF RADIOACTIVITY UPON ATOMIC THEORY. METHODS OF COUNTING ALPHA PARTICLES. THE SPINTHARISCOPE. BY A. W. KRAMER

IN THE EARLY chapters of this work, the fundamental structure of matter and the nature of electricity were explained in terms of the electron and its positive counterpart, the proton. The idea of a complex

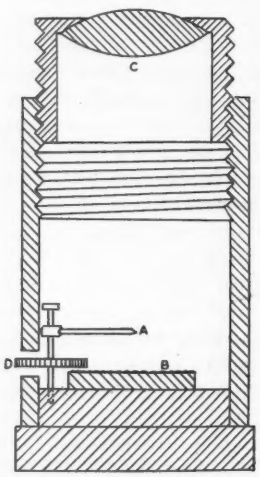


FIG. 1. THE CROOKES SPINTHARISCOPE

atom composed of a number of elementary parts, it was shown, had been held by a number of curious individuals but it was not until the discovery of the X-ray that any evidence of this fact was available.

With the discovery of radioactivity, however, and an understanding of its action, proof that the atom was a complex structure was positive; the idea of an atom as an ultimate indivisible thing was gone; in its place there was shown to be a complex structure endowed not only with a multiplicity of parts but with motion and energy as well. This was a revolutionary factor in chemistry and physics, for not only did it once more hold forth the promise that the alchemist's dreams of transmutation might come true, but in the heavier elements it was happening spontaneously. We have seen, in the several preceding chapters, how uranium, over a period of billions of years, gradually is transformed into lead. In this process of successive transformations, electrons and alpha particles are ejected at tremendous velocities. These velocities are so great that despite the small mass of the particles, the energies are sufficient to make themselves manifest in various ways.

An atom bears about the same relation to an object the size of a baseball, that a baseball bears to the earth.

Knowing the extreme smallness of the atom, the older physicists who evaluated the number of billions of atoms contained in the smallest portion of matter perceptible to the senses, would have scouted the implication that a single atom of matter might make itself evident to the senses. Such an idea was preposterous and utterly beyond the bounds of conception. Frederick Soddy[1] recounts the reactions, or perhaps we should say the emotions, of a distinguished foreign visitor when the question was under discussion at a British Association meeting. A single atom of matter! A single atom of matter! Repeating this exclamation over and over again, this man, whose years had been spent at the microscope on the borderland between the perceptible and the imperceptible worlds, was profoundly moved by the very idea of a single atom making itself known. Yet in radioactivity, this thing so utterly beyond the power of the imagination to conceive, is possible.

The smallest quantity of radium that can be detected by the aid of the gold leaf electroscope by means of the alpha particles emitted, is one three-thousand millionth of a grain. Since half a grain gives out a few thousand million alpha particles every second, the smallest quantity of radium detectable by the ordinary electroscope gives out only a few individual alpha particles every second. Thus, from the very early stages of the science,

*All rights reserved.

[1]The Interpretation of Radium and the Structure of the Atom.

it appeared not inconceivable to Rutherford that a discontinuity in the emission of alpha rays might actually be detected by using a minute quantity of radium.

The Crookes Spinthariscope

In an instrument known as the spinthariscope, devised by Sir William Crookes, this problem was solved almost unawares. Crookes found that if a screen coated with zinc sulphide and exposed to the radium radiations was observed under a low powered microscope, it became luminous. This is the basis of the spinthariscope. This instrument, as pointed out by Soddy, is the only genuine

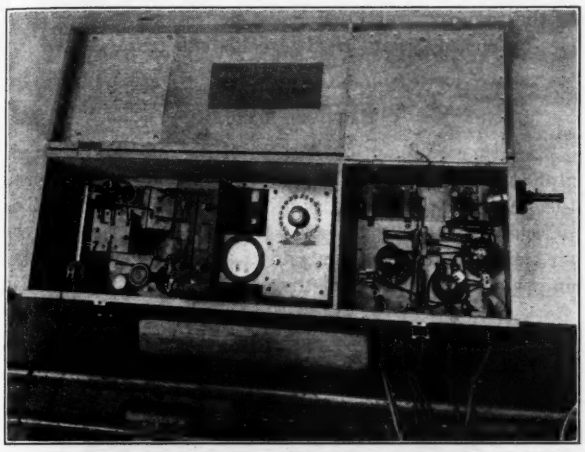


FIG. 2. GEIGER APPARATUS FOR COUNTING RADIOACTIVE RAYS. (PHOTO, COURTESY GENERAL ELECTRIC CO.)

instrument worked by radium that can be bought, radium and all, for approximately five dollars. The reason for this apparent paradox is to be found in the fact it is in the essence of the result to be obtained, to reduce the amount of radium to the smallest possible quantity and this unusual condition allows of a practically unlimited number of spinthariscopes to be made out of an almost invisible quantity of radium bromide. The amount of radium in each instrument is absolutely unweighable and invisible.

A section of the instrument is shown in Fig. 1. A needle, A, is made to touch a tiny phial *which once contained radium* and is then mounted centrally in a small brass tube at the bottom of which is a phosphorescent screen, B, coated with zinc sulphide. At the other end is a lens, C, for magnifying the screen and, by means of a little screw, D, outside, the needle point may be moved nearer to or farther from the screen.

"If, now," says Soddy, "in a dark room the screen is observed through the lens, it will be seen to be luminous and this luminosity can be concentrated or spread out by screwing the needle point nearer to or farther from the screen. After the eye has become accustomed to the darkness, it will be seen that the luminosity is not just a quiet continuous glow but shows discontinuity. It resembles most nearly a shower of shooting stars. Bright momentary flashes of light or scintillations, too numerous at any instant to count, are appearing and disappearing in the field of vision. This minute, insignificant trace of radium is positively belching forth alpha particles."

Each flash, the result of the impact of a single alpha particle with the atoms in the screen, lasts but one forty-thousandth of a second, so that its momentary brilliance must be exceedingly great.

That the incessant bombardment of the screen can be caused by such an infinitesimal amount of radium seems incredible, yet so it is. In a month's time, if the instrument is re-examined, the scintillations are as numerous and as brilliant as before. After a time, perhaps a year, the phosphorescent screen itself will be worn out by the continual bombardment of the alpha particles and will become insensitive. If, however, it is replaced by a new one, the radium will be found as active as ever and in another year's time this screen will be worn out. Replace the screen year after year until the owner of the instrument passes away, hand it on to his heirs and successors—even his race will probably have been forgotten before the radium shows any appreciable sign of exhaustion.

When we stop to consider this marvelous action—when we contemplate this mighty swarm of particles streaming out from this minute quantity of radium through the centuries, we get some idea of how small an atom of matter is. A grain of radium bromide expels every second about ten thousand million alpha particles. When we think of this number being emitted each second throughout centuries, we also can begin to realize how many atoms there must be in a single grain of mat-

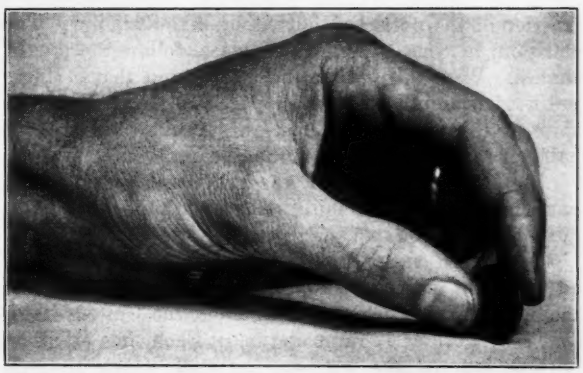


FIG. 3. A PIECE OF URANIUM WHICH BECAUSE IT IS BOMBARDING ITSELF AWAY WILL, IN FIVE BILLION YEARS FROM NOW, BE HALF LEAD

ter. The philosopher of a generation ago would have ridiculed the hope that we should ever be able to look through a magnifying glass to see the effect of a single atom of matter, yet each of the scintillations of the spinthariscope is nothing else.

Dr. Geiger's Apparatus for Counting Alpha Particles

While each of the scintillations in the spinthariscope represents the effect of an atom, the points of light are very numerous and therefore difficult to count. By means of an apparatus devised by Dr. Geiger, the coworker of Professor Rutherford, it has actually been made possible to count the number of alpha particles expelled from a given quantity of radium every second. In the apparatus, alpha particles emitted by a radioactive substance enter an air chamber through a thin aluminum "window" before which the substance is held. The particles ionize the air within the chamber,

making it electrically conducting. A current is, therefore, produced across two electrically charged points within the chamber and by means of a vacuum tube amplifiers, this current is amplified to such an extent that it can be heard in a loud speaker. The effect of the explosion of the radioactive atom is heard as a sharp click. Thus by holding a piece of uranium or radium in front of the window and by listening to the clicks, one can by the aid of a stop watch count the atoms entering the apparatus each second.

Of course, since the window is very small and since the alpha particles proceed in straight lines, only a small

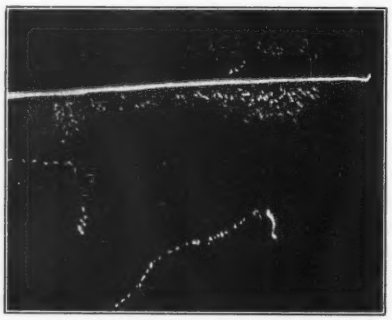


FIG. 4. CONDENSATION TRACKS OF ALPHA AND BETA PARTICLES PRODUCED BY C. T. R. WILSON'S METHOD

fraction of the particles emitted enter the window. The emission, in time as well as in space, follow the law of chance. With this equipment, it is found that a single grain of uranium emits 5000 particles per second. In spite of this, however, a piece of uranium will be but half gone in five thousand million years.

In the case of radium, the exact number of alpha particles emitted per milligram was found to be 136 million per second.

With such an apparatus, the General Electric Co. on the night of August 10, 1929, broadcast the voice of the atom to radio listeners throughout the United States over a network of 42 radio stations. Each time an alpha particle entered the window, the click which resulted was sent throughout the length and breadth of the land. It was the smallest voice ever heard—the voice of the infinitesimal.

In discussing the cathode ray in Chapter XV[2], it was shown that the stream of electrons emitted from the cathode is deflected by a magnetic or electric field and that the angle of deflection is a measure of the speed of the particles. As early as 1903, Rutherford had started experiments of a similar nature with the radiations from radium to settle definitely the nature of the alpha particle and to determine if possible the velocity with which it moved.

Since both alpha and beta particles carry electrical charges in traversing magnetic and electric fields, they suffer deflection, the amount of which is easily measured by reversing the fields and scaling the distance between the two traces made on a photographic plate. It was found much more difficult to obtain measurable deflections of the alpha rays than of the beta rays. With a magnetic field of 10,000, the radius of curvature of the alpha rays was about 40 cm. while an electron moving with a speed due to a fall through 400 v. would, in such a field, have its path bent into a circle of but 1/15 mm. radius.

By causing the particles to pass through very strong electric and magnetic fields as described, and measuring the deflection, it was found that for the alpha particle carrying two charges of positive electricity the ratio of $\frac{\text{charge}}{\text{mass}}$ was 4823 while, if the alpha particles were helium, the value of this ratio as calculated from experiments on the charge carried by the hydrogen atom in electrolysis should have been 4826. The agreement between these two figures constitutes a striking illustration of the accuracy with which the deflections of the particles by magnetic and electric fields can be measured.

C. T. R. Wilson's Method of Photographing Particle Tracks

Another method of detecting the effects of single alpha particles is due to C. T. R. Wilson, who caused the particles to pass through supersaturated air. The particles in their mad rush through the atoms of the air, ionize many of them and these ions serve as nuclei on which the excess moisture condenses. Thus a track

FIG. 5. A PARTICLE TRACK WHICH SHOWS THE RECOIL OF THE ATOM FROM WHICH THE PARTICLE HAS BEEN SHOT OUT

of water droplets is produced which can be photographed. An alpha particle from radium C, which has a range of 7 cm. in air, produces in this distance in its path about 235,000 pairs of ions, each of which serves as the nucleus for a drop of water. When a similar experiment was made with beta particles, the drops were very much less densely crowded. The tracks of the alpha particles are shown in the upper portion of Fig. 4 while that of a beta particle can be seen below. The photograph reproduced in Fig. 5 was obtained when a trace of radium was mixed with the supersaturated air. The interesting point to note in this case is that at the commencement of the track there is visible a minute trace due to the recoil of the atom from which the particle was shot out. This trace is scarcely visible on the reproduction but on the original plate was about 1/8 mm. long.

Wrought iron gets its celebrated toughness from its fibrous structure. Under the microscope, the fracture of wrought iron shows a grain like that of hickory.

[2]Electricity—What It Is and How It Acts—Volume I, page 146.

Pumping Water With Air Lifts

GENERAL PRINCIPLES, CALCULATION OF AIR REQUIRED AND GENERAL DISCUSSION OF TYPE USED

ESSENTIALLY, the air lift consists of a discharge pipe and a smaller air pipe both partially submerged in a well. The air pipe conducts compressed air to a device known as the footpiece, located at the bottom of the discharge pipe in such a way that the compressed air will be introduced into the bottom of the discharge pipe in a finely divided state. The mixture of air and liquid formed by this method in the discharge pipe is lighter than the head of liquid outside the pipe, consequently the mixture rises to the surface.

In many air lifts, the air pipe passes down outside the discharge pipe but sometimes, where the well diameter is not enough, the air line passes down the inside. While the principle of operation remains the same in these two cases, different types of footpieces are needed.

Figures 3 and 4 show types of air lift footpieces or pumps for various conditions. Figure 1 shows diagrammatically the general arrangement of an air lift, illustrating the terms used in connection with it.

AIR LIFT CALCULATIONS

Static head is the distance from the surface of the ground to the standing water level in the well when not pumping. Drop is the distance the water level falls when pumping a certain amount of water. Lift consists of static head plus drop plus elevation. Submergence is the depth that the air pipe is submerged below the pumping level in the well, either pumping or not pumping. Per cent submergence is the ratio expressed in per cent, of submergence to the sum of submergence and lift.

For convenience in making air lift calculations, Fig. 2 gives air consumption for various lifts at various recommended maximum and minimum submergences.

Two chief losses in the discharge pipe are the slippage of the air through the water and the friction of water in the discharge line. There is also an entrance

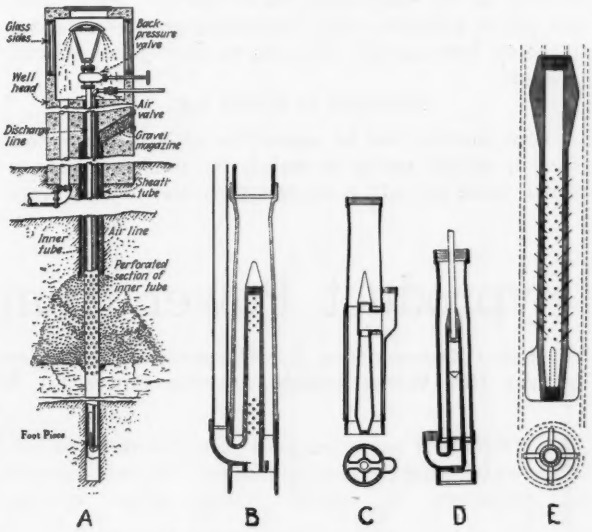


FIG. 3. SEVERAL TYPES OF FOOTPIECES

A—General design of the Air Made well. B—A standard type of footpiece. C—A footpiece for sizes above 8 in. D—Footpiece with automatic plunger for low submergence and low lift. E—Footpiece for central type of air lift.

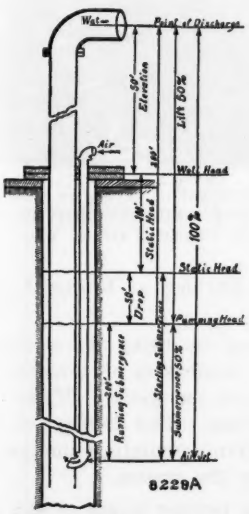


FIG. 1. GENERAL ARRANGEMENT OF A TYPICAL AIR LIFT

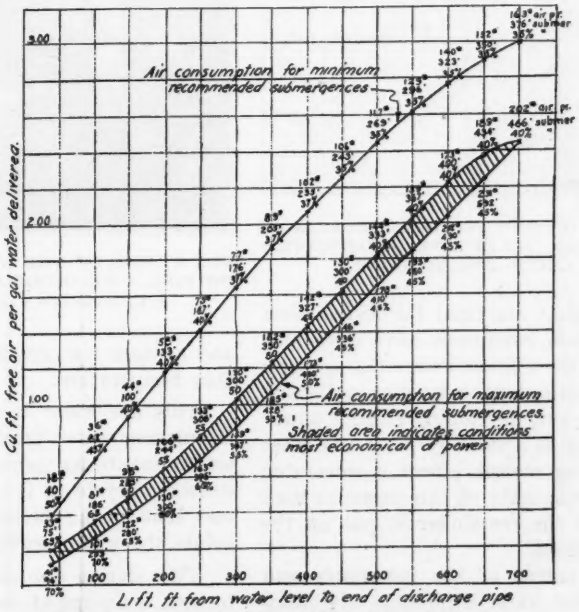


FIG. 2. CURVES FOR SIMPLIFYING AIR LIFT CALCULATIONS

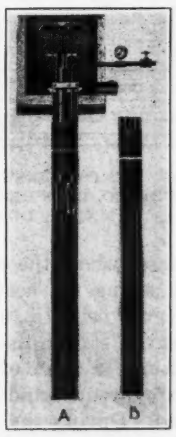


FIG. 4. TWO TYPES OF AIR LIFTS

A—Type VA pump, air entering from outside discharge pipe. B—Type VC pump, central air pipe system.

loss at the footpiece. Finally, it is desirable that the water should have a constant velocity throughout the length of the discharge pipe. The object in designing therefore should be to keep the sum of all losses at a minimum, since they cannot all be eliminated and since certain entrance and discharge velocities must be adhered to.

In wells in which an excessive drop is encountered, some means is usually provided for pumping off the head to prevent the starting pressure from exceeding the capacity of the compressor. Sometimes this is done by an auxiliary air jet or starting pump and sometimes by various arrangements of regulating valves on the air lines.

Aftercoolers are recommended just ahead of the air receiver at the compressor, to reduce air temperature and collect moisture, while separators are recommended in the air line near the well head to remove both oil and moisture.

Air Lifts in Sandy Soil

Back blowing can be applied to wells in sandy soil. The top of the casing is sealed, the discharge pipe is closed while the lift is in operation and air is forced through the footpiece, driving the water out and floating the finer sand. Then by opening the discharge part of the sand is washed to the surface by the reversal of flow and the process can be repeated until all fine sand outside the strainer is drawn out and gravel collects around the strainer.

Figure 3 A shows a special construction known as the Air Made Well for substituting gravel for sand in back blowing. The sheath tube around the entire well casing is first driven to hard pan and gravel is fed between sheath and well casing. This sheath is then withdrawn gradually while back blowing pumps out the sand, allowing the gravel to replace it. The sheath casing is withdrawn to uncover enough perforations to handle the inflow and after the well is completed, a cement passage carries gravel down to surround the well, the gravel bed being kept free from sand by back blowing. This construction, it is stated, has in many instances increased the original output of wells and reduced maintenance.

A subsequent article will show some typical installations of air lifts, with data on the compressors and operating characteristics.

Byproduct Power from District Heating Load

Using Exhaust from Non-Condensing Engines for Steam System and Condenser Circulating Water for Hot Water System, Illinois Power Co. Secures Economical Operation at Springfield, Ill.

ATTENTION has often been called to the possibilities of using for heating purposes the heat rejected to condensers in central station prime movers, in cases where the conditions are right for distributing and selling the heat. Such conditions have developed in Springfield, Ill., where the Illinois Power Co. operates a central station that supplies both hot water and steam systems for 8 mo. of the year, developing electric power as a byproduct and acting as a standby plant the other 4 mo. During the heating season, power is generated to balance the heating load; some of this power is used for electric railways and the remainder is put on the company's transmission lines.

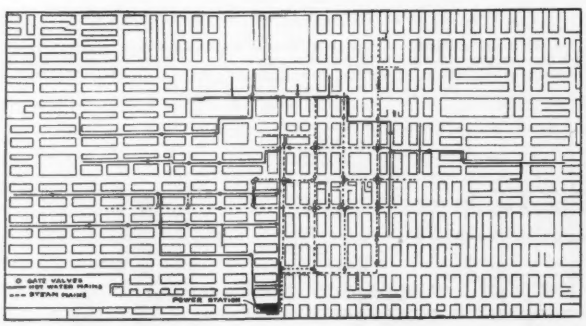


FIG. 1. MAP OF DISTRICT HEATING SYSTEMS OF ILLINOIS POWER CO. IN SPRINGFIELD. SOLID LINES—HOT-WATER MAINS; DOTTED LINES—STEAM MAINS

Figure 1 shows the extent of the hot water and steam heating systems. Hot water is piped to 434 buildings through about 30,000 ft. of 16-in. mains, with the same amount of return mains. Hot water for heating leaves the station at 70 lb. pressure and about 210 deg. A 2-lb. differential must be maintained at the residence and a water temperature of 180 deg. at 10 deg. F. outdoor temperature.

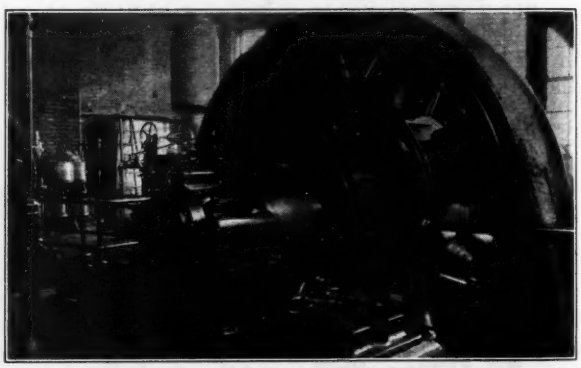


FIG. 2. ONE OF THE NONCONDENSING CORLISS ENGINES DRIVING A D.C. GENERATOR FOR RAILWAY SERVICE HAS A CONTINUOUS SERVICE RECORD OF 20 YR.

This hot water is obtained by using the condenser circulating water from the condensers of three of the six engine-driven generators in the station. These condensers operate at 5-in. vacuum. Two 1800-g.p.m. and one 1250-g.p.m., turbine-driven circulating pumps circulate the water required by the system.

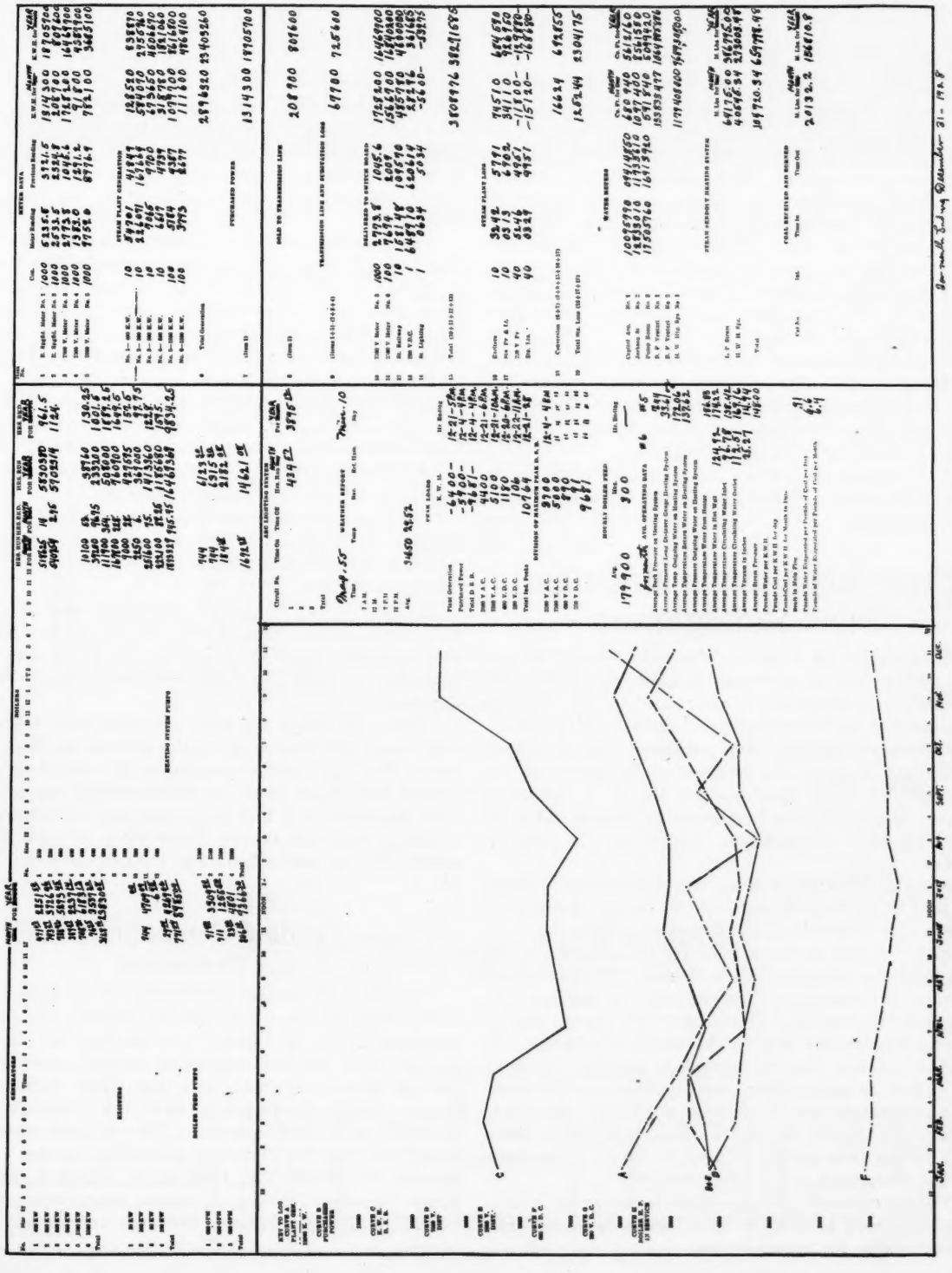
This station also supplies heating steam to 464 customers, including stores, garages, apartment houses and manufacturing establishments. This is carried by

25,000 ft. of 20-in. and 18-in. steam line, taking steam at 18 lb. pressure from the exhaust of three of the engines.

As shown on the accompanying station log for 1928, the station produced 38,271,585,000 kw-hr. in 1928, 9,689,348,000 lb. hot water and 659,798,480 lb. of steam. Three of the engines are simple, noncondensing Corliss units, one of 400 kw. and two of 800-kw. capacity. The other three are cross-compound condensing Corliss units, one of 800 kw. capacity and two of 1500-kw. capacity.

Steam for these units is supplied by 10 boilers, all fired by chain grate stokers burning Illinois, 9500-B.t.u. screenings. There are six 384-hp. boilers and two 500-hp. boilers operating with natural draft chain grates and two newer 922-hp. boilers with forced draft chain grates. The two large boilers are designed to operate continuously at about 225 per cent of rating.

During the heating season, one condenser usually



LOG SHEET SHOWING SUMMARY OF OPERATING DATA FOR DEC., 1928, AND FOR THE YEAR

supplies sufficient water for the hot water system, the others being available to make up any deficiency.

Generators No. 1 and No. 2 are 500-v. direct current machines that supply railway load, the others are 2500-v. alternating current machines that can supply power through transformers to the 13,200-v. transmission lines leading to Peoria. This is usually done in the coldest months between midnight and 6 a. m. so that there will be plenty of heat available for the heating system, the power being a byproduct.

There is also a 500-kw. motor generator set making 2500-v. a.c. that can be driven by the direct current generators when the railway load is low.

Thus the noncondensing engines supplying exhaust to the steam heating can be run at full load to get the steam, driving the motor generator set which makes 2500-v. alternating current, which can be sent out over the transmission system. This motor generator set can be reversed to make 500-v. direct current, driving it from the alternating current machines to keep them furnishing steam. Thus it is evident that, during the heating season, by proper balancing of the various steam and power loads, extremely economical operation can be obtained in which all power is a byproduct of the heat and is obtained at low cost.

Of particular interest at the Springfield plant is the No. 1 engine generator set shown in Fig. 2, which has been in practically continuous operation for 20 yr.

G. Mayer is superintendent of the Springfield plant of the Illinois Power Co. described here.

C. W. Organ is general manager in charge of all power and steam distribution systems for this division of the company.

Startling Claims Made for New Refrigerant

DISCOVERY of a new refrigerant which, it is predicted, will bring about a vast improvement in the world's environment, is announced by the Division of Industrial and Engineering Chemistry of the American Chemical Society. The substance was developed by Thomas Midgley, Jr., internationally known as the discoverer of Ethyl gasoline, and Dr. A. L. Henne, a Belgian chemist, in the laboratory at Dayton, Ohio, of the Frigidaire Corporation, subsidiary of General Motors.

According to E. M. Billings, secretary of the division, this will be an outstanding event in the development of automatic refrigeration. Commercial production, it is thought, will not be practicable for two years.

Use of the refrigerant, it is claimed, will enormously increase environmental opportunities by making possible wide application with safety of the cooling process both in the tropics and in the northern climates. A new environment can be created in sleeping rooms on hot nights; in mines, where operations are now retarded because workers can labor only for brief periods in warm strata at great depths; in submarines; and in situations arising from accidents in which danger from chemicals is threatened.

The refrigerant, yet unnamed, is non-toxic, non-inflammable and is said to have desirable engineering characteristics for refrigeration.

"It has been discovered," Mr. Midgley explained, "that several aliphatic compounds containing both fluorine and chlorine can be produced having these three features combined in a single compound. No refrigerant or mixtures heretofore used has effected this combination."

It is a compound of carbon, chlorine, and fluorine, technically known as fluoro-chloro-methane, and is a clear, white liquid, boiling at 18 deg. below zero Fahrenheit. Eventually, it is expected, this class of the fluoro-chloro methanes will replace all present refrigerants, chief among which at present are ammonia and sulphur dioxide.

Substitution of fluorine for either hydrogen or halogen reduces both inflammability and toxicity, and a sufficient number of cases have been investigated to justify the acceptance of this fact as a generalization. It is interesting to observe that this is contrary to accepted opinion based on experience in the inorganic field.

The conclusions of the researches, were borne out, first, through a preliminary investigation by Dr. Robert A. Kehoe of the Medical School of the University of Cincinnati, and later through more comprehensive studies, including animal experimentation, at the United States Bureau of Mines, Pittsburgh, under the direction of Dr. W. P. Yant.

Plans are under way for the manufacture of this substance, which, it is hoped, will be an accomplished fact within the next two years. It is now being manufactured in the Dayton laboratory at the rate of a few pounds a day for experimental purposes.

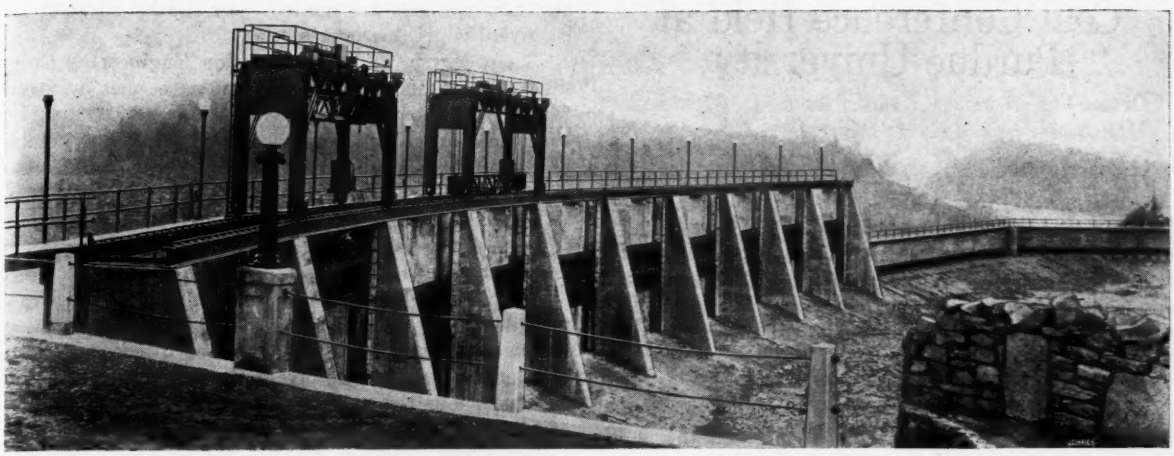
A 40 per cent concentration was not fatal to pigs exposed 40 to 60 hr. Dogs and monkeys exposed to a twenty per cent concentration for five days showed no deleterious effects.

A large group of guinea pigs, dogs, and monkeys were exposed seven hours a day for 60 days to a 20 per cent concentration without injury. A 20 per cent concentration makes a dog drunk, but he sobers up in less than a minute.

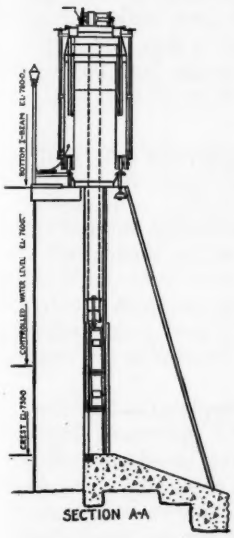
Tests comparing the new substance with other refrigerants were also made at the Bureau of Mines. A two to four per cent concentration of methyl chloride proved fatal in an hour. A similar result was reached with ammonia in a 1.25 to 4.5 per cent concentration. Animals lived one to two hours when exposed to an eighty per cent concentration of the new substance with air.

Triple Tandem Compound Turbine for Powerton

NEW TYPE of turbine generator is being built at the Schenectady Works of the General Electric Co. for the Superpower Co. of Illinois, at Powerton, Ill. Known as the triple tandem compound turbine generator, it has one electric generator and three steam turbine elements (high, intermediate and low pressure) all mounted on a single machine. Two of these units are being built for the Powerton generating station. Each is rated at 105,000 kw., 1800 r.p.m., 22,000 v., 600 lb. steam pressure, 725 deg. F. steam temperature, boiler reheat to 750 deg. between the high and intermediate stages.



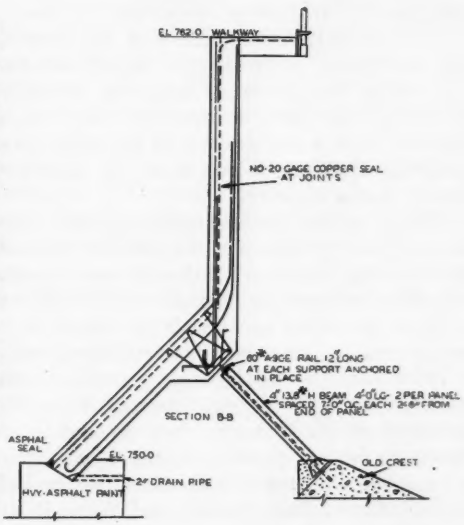
Kentucky Utilities Co. Raises Crest Level 10 Ft. at Dix Dam

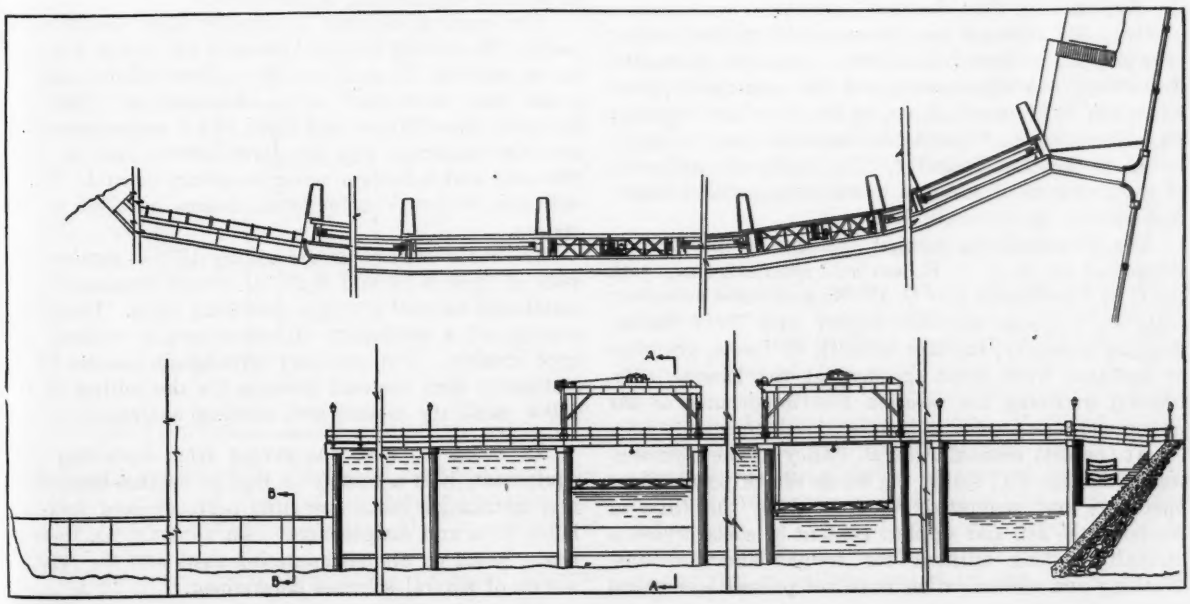


CREST GATES added to the spillway section of Dix Dam of the Kentucky Utilities Co. will raise the crest level from el. 750 to el. 760. This project, described on page 1061 of our October 15, 1925, issue, consists of a rock fill dam with a crest at el. 780. In order to avoid any possibility of flow over the dam proper a spillway capable of handling 200,000 cu. ft. was provided, although the maximum flow recorded over a period of 30 yr. was but 29,700 cu. ft.

Ten new gates 10 ft. high and 35 ft. wide (clear width between piers), raised and lowered by one of two gantry cranes, have been added. Beyond the 10 gates, flash boards of the type shown in section B-B have been added. These flashboards, balanced in place by a pivoted support, are designed to overbalance in sections beginning at el. 762, each additional half foot rise of the water level overbalancing another section. The water level at which the flash boards overbalance is determined by the position of the supports.

The gantry cranes are motor operated, electrical connections being made at the base of the lamp posts as shown in section AA. L. F. Harza of Chicago was consulting engineer.





Coal Conference Held at Purdue University

OPERATORS, DEALERS, CONSUMERS AND STOKER MANUFACTURERS MEET AT LAFAYETTE, APRIL 9—11

PURDUE UNIVERSITY, Lafayette, Ind., was the scene of the Third Midwest Bituminous Coal Conference, the success of which cannot be measured as well by the record registration of somewhat over 500, as by the influence of those present and their earnest and common desire to meet the problems confronting the industry and coöperate to make Illinois and Indiana coal supreme in local markets.

Held under the direction of Purdue University, the Coal Trade Association of Indiana and the Illinois Coal Bureau, with the University of Illinois and the A. S. M. E. coöperating, the conference dealt with the availability, classification and marketability of Illinois and Indiana coals for power, industrial and domestic uses. W. A. Knapp, professor of engineering extension, was chairman of the general committee.

A. A. Potter, dean, School of Engineering, opening the conference, outlined the important part Purdue University has played in industrial research for many years and the part it expects to play in the future. Purdue, with a registration of somewhat over 2700 engineering students, is said to be the largest engineering school in the country.

Many of the sessions dealt entirely with domestic uses of coal; problems of the retailer, mechanical stoker and heating engineer, although one complete session was given over to the discussion of Illinois and Indiana coal for industrial use, particular attention being given to the ceramic, glass and gas producer practice.

New problems of the coal retailer and efforts of the retailer to meet competition and raise the business standard of the industry were covered in considerable detail by several papers; among them, "The Dealer as a Fuel Counsellor in His Community" by B. R. Gebhart of the Illinois Coal Bureau and "The Relation of the Coal Industry to the Consumer" by George F. Klein of the Kansas City Coal Service Institute.

Over 300 attended the banquet held on the evening of April 10. Edward C. Elliott, president of Purdue University, was toastmaster, and the principal address was given by Homer R. Linn, of the American Radiator Co. Speaking on "Industrial Research and its application to the Coal Industry," Mr. Linn outlined some of the problems of the coal operator and stoker manufacturers in the domestic field.

The Twenty-Sixth Annual Meeting of the Indiana Branch of the N. A. P. E. was held simultaneously with the Coal Conference and C. D. Wilgus, state president, Lisle A. Pierson, national deputy and Fred Raven, national secretary, together with H. G. Leslie, governor of Indiana, were guest speakers at the banquet, Mr. Pierson outlining the position and importance of the power engineer in our industrial development.

At the first session, Alex D. Bailey of the Commonwealth Edison Co., stated the needs of the power plant operators and suggested research along the lines of reducing the ash and sulphur content of coals, which is annually costing millions for freight and corrosion. Washing and carbonization have not proved economical and new methods are needed. Mr. Bailey's paper will be given at greater length later.

T. A. Marsh, of the Combustion Engineering Corp., set forth six requirements which must be met by manufacturers of domestic and semi-industrial fuel burning equipment and in a session devoted to the reconditioning of existing plants to burn Indiana and Illinois coal economically, John Hunter, consulting engineer, told of methods which had been successful in some of the smaller power plants. This paper will also be given in greater detail later.

Justification of smoke abatement methods by Frank Chambers, chief inspector of the smoke department of Chicago, brought forth some spirited discussion during which Joseph Harrington predicted that restrictions will become more drastic and even short smoking periods of 5 or 10 min. per hr. prohibited. Examples of changes to household furnaces to give better combustion conditions were given by A. C. Willard, head, and A. P. Kratz, research professor of mechanical engineering, at the University of Illinois. Tests made in existing equipment show lower efficiency with local coals because of incomplete combustion. Research is now under way to improve combustion conditions so that both midwestern and hard coals can be burned with equal efficiency.

Switchgear for Springwells Pumping Station

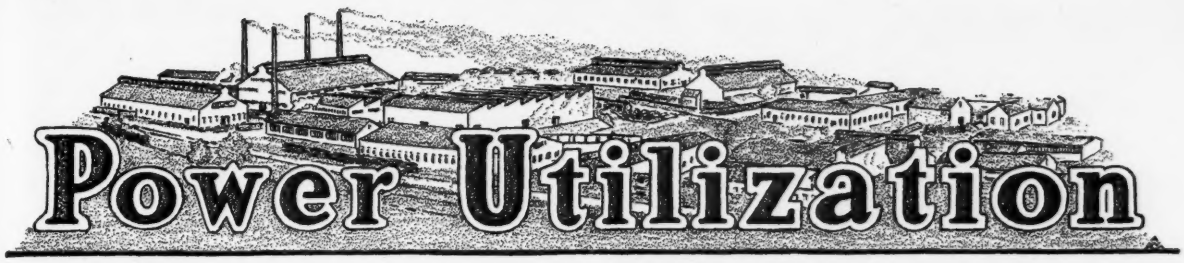
CONTRACT for the electric switching equipment for the pumping and power plants of the Springwells Station, City of Detroit, has been awarded to the Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa. This station will be the largest single pumping station ever built and it will be controlled by Westinghouse switchgear throughout.

While the station will be complete and modern in every respect, the motor control equipment has been simplified wherever possible, using standard equipment rather than any form of special apparatus. The desire of the Board of Water Commissioners and their engineers is to give the City of Detroit the finest example of modern engineering achievement.

The control includes about 160 steel switchboard panels, 75 current limiting reactors for power bus and motor starting, 27 steel circuit breaker cubicles and 53 metal clad switchgear units. In addition, there are included three 300-kw. and three 50-kw. motor-generator sets for excitation and auxiliary service and all field rheostats and induction motor secondary control. There will also be two Westinghouse stokers installed in the station.

The main switchgear controlling 4600-v. service consists of type B-16 and B-26 oil circuit breakers in 53 metal-clad vertical lift type switching units. Each unit consists of a stationary structure and a vertical lift type breaker. The auxiliary switchgear consists of 27 stationary steel enclosed cubicles for the control of the 460-v. auxiliary motors and starting equipment.

IN ORDER TO FIND the saving from installing new equipment, it is necessary to find or assume equipment and installation costs, operating performances, fuel and labor costs and maintenance. An analysis can then be made, based on annual operating costs and the relative merits of several schemes determined.



Maintenance of the Piping System

ADEQUATE PIPE TUNNELS, WELDED PIPING, PROPER WATER TREATMENT, THOROUGH INSULATION AND RECORDS OF WORK DONE REDUCE COSTS. BY C. C. WILCOX*

ALTHOUGH the following discussion pertains more particularly to conditions existing in the Studebaker automobile plant at South Bend, it applies in many ways to other large industrial and manufacturing plants in which the piping systems for steam, water, air, oil, and the like are large. Specific information is sometimes more valuable than generalities which lack definite application, so we will be as specific as possible.

RESPONSIBILITY FOR POWER GENERATION AND USE

Total cost of operating the Power or Service division is obviously composed of two factors,—the unit cost of the service rendered (as the cost of electricity per kilowatt-hour; the cost of steam per thousand pounds; the cost of water per thousand gallons), and the quantity of service rendered.

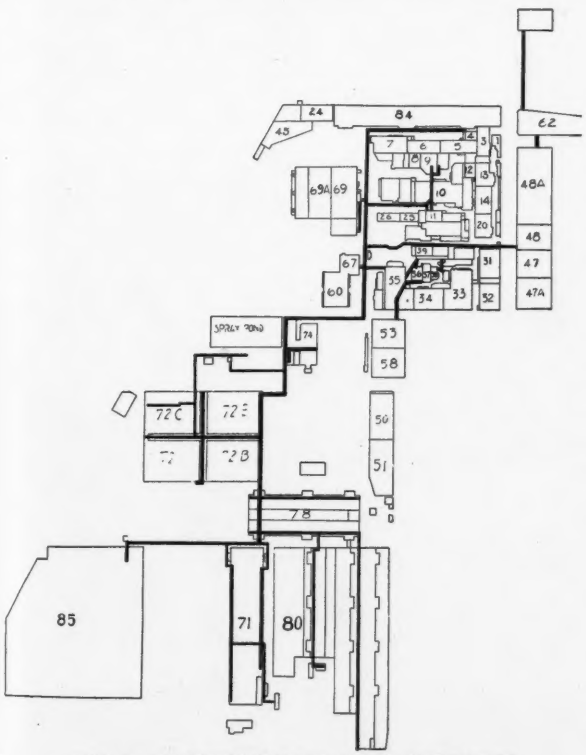


FIG. 1. TUNNELS CARRY ALL LARGE PIPE

These two factors find their counterparts in the plant organization; The power plant personnel being responsible for unit costs and the production organization largely responsible for the quantity of service rendered; a divided responsibility that is more or less necessary but which lacks the elements of incentive necessary to get automatically the best results. For this reason, joint responsibility for utilization is vested in the power plant personnel and productive departments utilizing the service.

Production of steam, electricity and compressed air is a complicated and highly specialized business, for which is built up a specially selected and trained organization that delights in the skillful operation of the power house and so is in a position to get satisfactory unit costs. This aspect of the situation makes the first factor by far the easier to control.

The other factor,—that of quantity of service rendered—has to a less degree the advantage of centralized responsibility. It is controlled by the more or less accidental interest of hundreds of foremen and thousands of workmen, as well as the standard of maintenance adhered to in the apparatus distributing and using these commodities. The system is scattered over a large territory, which increases the possibility of trouble by exposure to unauthorized tampering, also the difficulty of routine inspection. In the interest of securing a proper balance between these two factors of cost, Studebaker has given considerable attention to the second factor,—the orphan, so to speak. This article deals with certain features of pipe maintenance and construction as affecting the efficiency of distribution and utilization of this class of service.

PIPE TUNNELS SHOULD BE AMPLE AND CLEAN

Distribution of steam, water, oil and air is accomplished through a fairly commodious tunnel system serving the principal building as shown in Fig. 1. This is the backbone of the distributing system. It should therefore be supplied with adequate openings, easy of access and located in key positions. It should be ample in size to permit workmen to carry on repairs; all high temperature piping should be covered and the tunnel should be well drained, well lighted and clean. These points seem too obvious to need mentioning but tunnels are proverbially neglected. It can always be demonstrated that cleanliness and order are the certain fore-

*Superintendent Power Division, The Studebaker Corporation, South Bend, Ind.

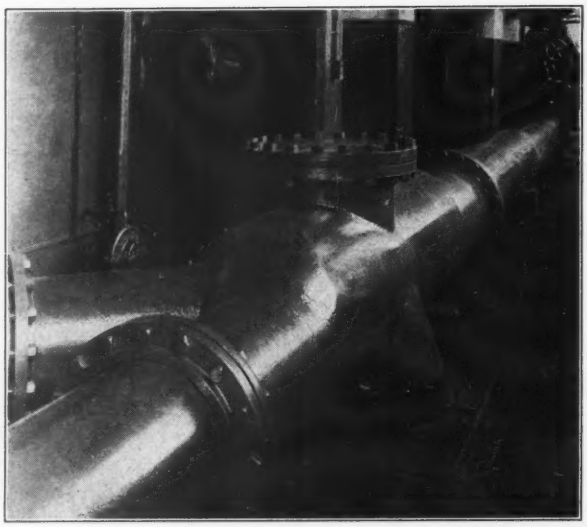


FIG. 2. STEEL WELDED FITTINGS ARE TIGHT

runners of good maintenance and careful operation and a hot, dirty, dark tunnel will certainly not be inviting to the maintenance men, with the cumulative effect of requiring more than normal maintenance while getting less than the needed attention.

Expansion Bends and Welding Cut Costs

Long runs of steam piping in tunnels require provision for expansion and a common method is to use slip expansion joint. These leak frequently and to pack one of them (12-in.) requires $50 worth of packing and several hours of overtime with the pressure off. For this reason, these joints have been replaced by expansion loops wherever room is available, which has increased reliability and safety and decreased maintenance and steam losses. One exception to the application of the loop is the 24-in. low-pressure main in the tunnel which would have required more space than was available. Here the slip expansion joint had to be used but, since the pressure is low and the line is infrequently cooled off, it is found that an amorphous metallic packing holds quite well.

Ease of welding pipe and the low cost of fabrication by this method has led to its adoption as a standard for practically all pipe work. Nothing contributes more to the poor condition of tunnels than leaky flange joints in large pipe. All these joints have been replaced by gas welding the pipe and trouble from this source has been forever stopped. One 12-in., 200-lb. steam line, about 2100 ft., of welded construction with expansion loops, has had no maintenance whatever since its installation four years ago and, barring accidents from outside sources, it never will require maintenance.

Many times, the inability to get into a tunnel to make repairs with the pressure on results in operation of a line for long periods before production will permit of interruption to service for purposes of repair, even to stop a serious leak. With the main tunnels under perfect control, it is possible to shut off lines when service is not needed and so make considerable savings in the quantity of service rendered. This is a powerful tool in controlling the total cost of operation because department foremen have production troubles of their own and are likely to neglect shutting off lines not in use.

A good example of welded construction is shown in Fig. 2, which is a 30-in. condenser discharge header that replaced flanged cast-iron pipe and fittings. The steel fitting shown was fabricated by Studebaker maintenance men.

Figure 3 is a typical tunnel view showing two 12-in. 200-lb. steam lines above and the 24-in. low-pressure steam line on the floor. This spot was not specially cleaned up for photographic purposes but is typical of the main tunnel everywhere except as to size. Small electric driven sump pumps are used in places where water is liable to get in from the outside.

Special attention has been directed to the tunnels because they constitute the "backyard" of the system. The grade of maintenance in the out-of-the-way places is a good indication of the state of mind of the maintenance men and of what you can expect in places where inspection is not easy.

Records and Their Study Uncover Bad Conditions

The table is a resume of all the pipe maintenance in the plant for a period of thirty-five days. These records are not kept continuously but are made periodically to uncover any condition that ordinary observation and the usual records do not disclose. Such information is comparatively easy to get by requiring each man to write up a ticket for each job, be it ever so small. His accuracy can be checked by comparing the aggregate time on his tickets with that on his time card but we find this unnecessary, after explaining to the men the purpose of the record and so enlisting their enthusiastic interest.

It will be noted that one of the main items of repair in Buildings 69 and 47-48 is the return lines. As a result of this information, an extended study was made

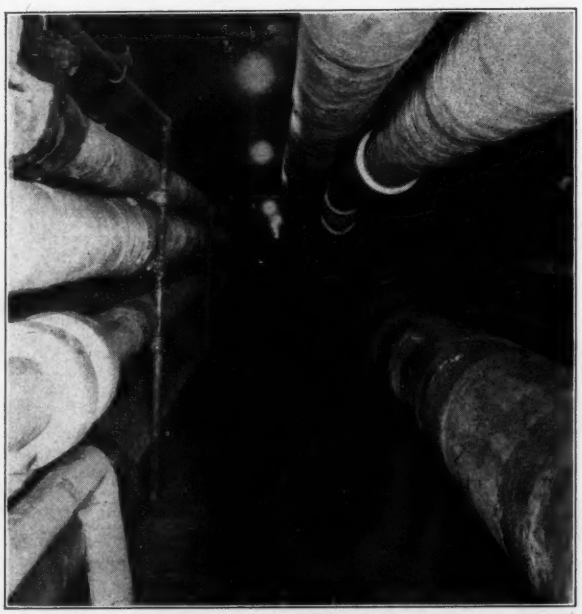


FIG. 3. PIPE GETS GOOD ATTENTION IN A TUNNEL LIKE THIS

MAINTENANCE RECORD, 35 DAYS

	BODY PLANT		BODY PLANT		DRY KILN		OFFICE		MACHINE SHOP		SHIPPING		BODY STAMPING		BODY WELDING		MISC PARTS		MACHINE SHOP		TOOLS DIES GEARS		FOUNDRY		SPRING SHOP		FINAL LINE		FORGE SHOP		WOOD MILLS		OFFICE		TUNNEL		TOTAL		% TOTAL
BUILDING NO.	84		47-8		69		1&33		60&67		11		53		24		79		72		78		85		86		82		71		35		96		TUNNEL		TOTAL		% TOTAL
	J	H	J	H	J	H	J	H	J	H	J	H	J	H	J	H	J	H	J	H	J	H	J	H	J	H	J	H	J	H	J	H	J	H	J	H	HRS
NEW WORK	15	40	2	9	1	2½					1	2							25	54	20	46¾	41	179	5	16	1	1	15	31	6	19					132	400½	150
CHANGES					1	3	1	3½			3	13	3	8½	3	11	10	68	22	41	6	11¾			8	23	3	9	27	54½	4	20					91	263½	9.9
RETURN LINES			11	43	58	151	14	29			9	29	6	15½	1	4															10	22½			3	9½	112	303½	11.4
TOILETS	31	111½			1	1					2	6½	16	45¾			1	3	7	17	4	17	11	23¾	7	14	8	14			1	9	3	5½			92	267	10.0
RADIATION			2	5¼	4	16½			2	4½			2	8½			9	20¾	22	45	12	27¾	5.5	36	7	12	24	67¾					3	3½			102	246¾	9.2
AIR PIPING	19	27			2	4			1	1½	2	11½	3	3½	1	1½			29	22¾	8	10¾	37	38¾	5	5	4	7½	5	50¾					2	11	164	174¾	6.6
FLOOR DRAINS	15	76½			2	7¼					2	5	1	1							6	10¾	4	11½			6	18	9	22	4	5¼					49	159	5.9
OVEN COILS	36	68½																																			36	136	5.2
WATER PIPE	8	19			5	6¾	6	15	2	8					2	1½	1	4	16	22¾			13	12¼	3	11	8	12½	15	12½	1	1					80	126	4.7
STEAM PIPE									1	1¼			11	19¼			10	20											62	63¾	3	11½					87	106	4.0
GAS & OIL PIPE					4	12½															5	5¾			7	26¾											16	45	1.8
HYDRAULIC SYS.													28	56¾					3	3½																	31	61¾	2.3
STEAM TRAPS			1	2							2	3½											6	19											1	2	10	26½	1.0
AIR HOSE																							42	75¾					19	18¾							61	94½	3.6
FROZEN LINES	2	7	3	23¾	1	1½			3	8¼					2	2									2	1¾	18	25									31	59¼	2.1
OXYGEN "																	5	3¼																			5	3¼	.12
GASOLINE "																	1	1	10	15							1	2									12	18	.7
SOLUBLE OIL "																			22	28¾	6	12															28	40¾	1.5
ENAMEL "																											2	1¾									2	1¾	.1
PROCESS STM. COILS																					12	20¾															12	20½	.8
GAS & OIL BURNERS																							18	29					29	29							47	58	2.2
EXPANSION JTS.																																			3	23	3	23	.9
																																					1203	2674	

J = NO. OF JOBS
H = NO. OF MAN HOURS

of the cause of the trouble. Investigation disclosed that it was corrosion and that it was confined almost entirely to the high-pressure returns which happen to come from sources free from oil.

At first, it was suspected that the return condensate carried some reagent of a corrosive nature of which we were ignorant but laboratory analysis of samples of condensate failed to reveal any such content. Further tests disclosed the fact that the return condensate contained enough dissolved oxygen and CO_2 to cause the trouble and that the low-pressure returns carried just enough oil to afford pipe protection, which the high pressure returns did not have.

Figure 4 shows how the pipe threads are affected by this corrosion, both the 5-in. and 1½-in. samples being taken from high-pressure return lines in Building 69, the dry kiln building. This again emphasizes the disadvantage of screwed work compared to welded, which is not weakened by threading and resists corrosion much longer, even though the action be present.

Proper Water Treatment Reduces Pipe Repairs

Considerable pipe maintenance may be caused by the character of steam and return condensate carried. Improper boiler water treatment may be responsible for scaling up piping by deposit of solids from the water and this will eventually lead to improper operating conditions due to reduced pipe capacities and to ultimate necessity for cleaning. Where scaling is considerable no internal treatment for removal of scale has been found that is as satisfactory as replacing the pipe. This is a major operation, but it may be necessary.

Figure 5 shows what happened a few years ago in a line to the feedwater heater in the old boiler plant known as Station B, this line being completely put out of commission by the accumulation of scale. Change in water treatment was necessary to eliminate recurrence of this condition. This change has been made and it is now possible to operate indefinitely with no scale whatever in feed pumps or piping. It is an internal boiler water treatment that permits carrying high concentration, thus reducing tube loss and boiler blowdown and, above all, producing perfectly clean steam, the condensate from which is alcohol clear. The nature of the treatment is foreign to this discussion.

This change in water treatment has revolutionized many conditions in the plant and the savings in cost are almost unbelievable, a large part of which consists of reduced pipe maintenance on steam lines and traps out in the factory. The total square feet of equivalent direct steam radiation for all purposes in the South Bend plants is in round numbers 1,900,000. Nearly

FIG. 4. THREADS ON CONDENSATE LINES CORRODED BY OXYGEN AND CO_2

FIG. 5. THIS SCALING WAS STOPPED BY PROPER WATER TREATMENT

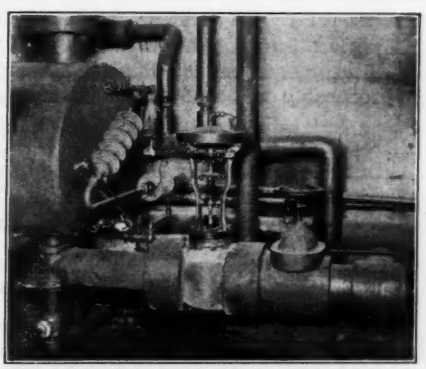


FIG. 6. CENTRAL DRAINAGE FOR DRY KILN BUILDING

6000 traps of all kinds are required to handle this radiation and any water or steam condition that will foul these traps is indeed a serious matter as regards interruption to service, steam loss and subsequent maintenance cost.

Boiler water treatment therefore stands out as the predominating cause of pipe maintenance work. A steam or water carrying dissolved oxygen is powerless to do much damage to the pipe walls as long as they are protected by a coating of scale or oil, or both, but, when proper boiler water treatment has cleaned the surfaces

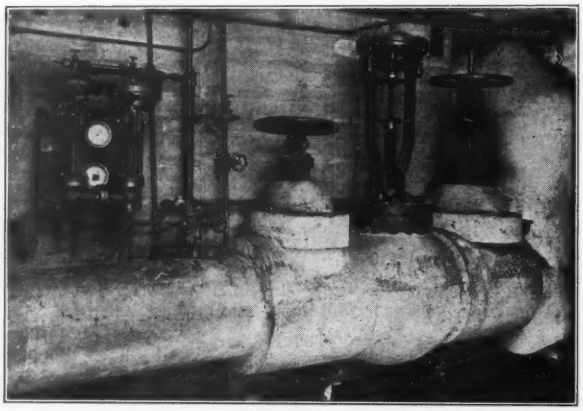


FIG. 7. REDUCED HIGH-PRESSURE AND EXHAUST PROCESS SUPPLY ARE MASTER CONTROLLED

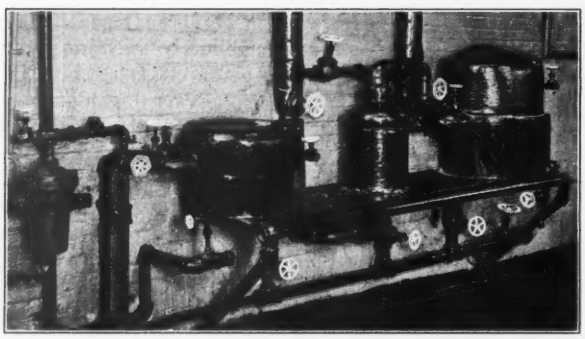


FIG. 8. TRAPS ARE FITTED WITH REMOVABLE INSULATION

of the pipe, it becomes necessary to give attention to deaeration of feedwater to prevent corrosion of pipe as shown in Fig. 4. That pipe was perfectly clean but analysis of return condensate showed dissolved oxygen 0.8 per cent, a pH value of 7.3 per cent and total solids of ½ grain per gallon. This is a corrosive water and will probably be benefited by deaeration.

Condensate Drainage and Process Steam Supply

In some locations, it has been found advantageous to substitute a special drainage device for a group of thermostatic traps as in the dry kiln building. Here a group of about 200 thermostatic traps, each serving a steam coil in the dry kiln cells, has been replaced by the drainage device shown in Fig. 6. The receiver at the left is under vacuum and carries a condensate level determined by the radiating discs shown on the end of the tank. Pressure generated in these radiators operates the valve as shown through a connecting tube. This has eliminated heavy maintenance on a group of individual traps and reduced steam losses by centralizing the control. The tank is under vacuum and the control is removed from the heat of the dry kilns and is, therefore, subject to better inspection than were the individual traps.

It sometimes happens that live steam connections are required to supplement the use of exhaust steam where the pressure of the latter varies and therefore at times is not available, or the pressure is too low. The ordinary arrangement of a pressure reducing valve on the high-pressure line, set to cut in at a certain pressure,

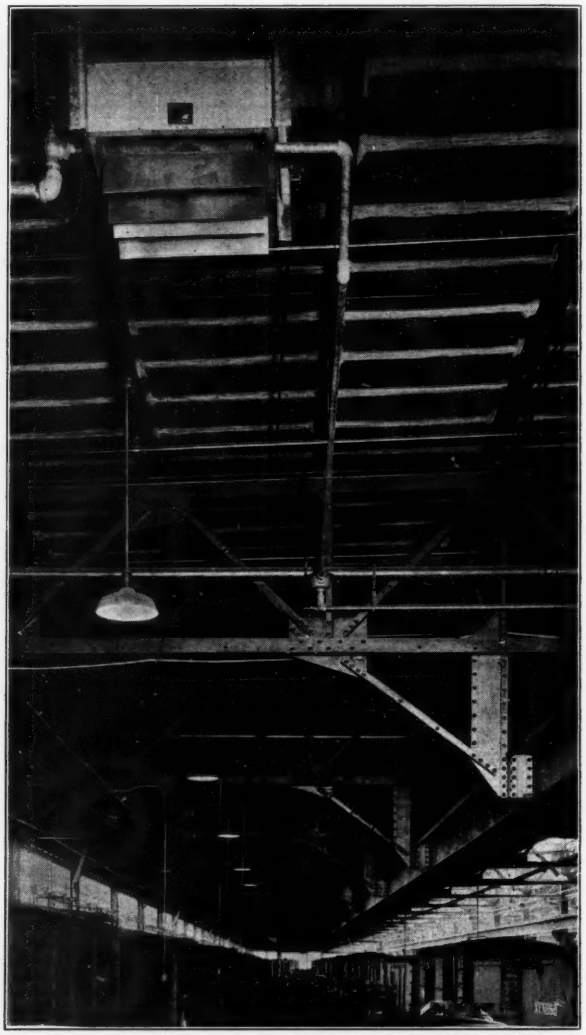


FIG. 9. UNIT HEATERS REDUCE PIPE DAMAGE

may not be enough because of the fact that this may be the only department requiring steam at the time and, if so, the high-pressure steam can pass the reducing valve, then back up in the factory low-pressure system, where it is not needed. Positive closing of the exhaust supply valve must then be simultaneous with the opening of the high-pressure supply.

This has been accomplished by a master control shown in Fig. 7 so that, by the positive and simultaneous operation of both high and low-pressure supply valves, steam is saved that formerly was wasted. Only

the exhaust valve shows in the cut, the high-pressure valve being located elsewhere. Both are operated by compressed air, through the master control governor shown at the left.

Unit Heaters Save Pipe Damage

Destruction of wall radiation by trucking in aisleways has been prevalent, even though guards have been provided for the pipe and penalties for the drivers. This has resulted in many heating complaints, loss of steam and high cost of maintenance. This difficulty has been eliminated by the installation of unit heaters, the advantages of which are becoming well recognized in factory heating.

Figure 9 shows a typical installation in the shipping dock, where maintenance has been practically eliminated by replacing wall radiation with the unit heater. In many places the unit heater cannot be used, for instance in the pickling house where sulphuric acid fumes are very destructive. Unit heaters had to be removed from this service and wall radiation installed.

Pipe Covering Saves More Than Heat

It should be unnecessary to mention the desirability of keeping all high-temperature pipe covered with proper heat insulation but, oftentimes, changes in plant arrangement or damage to covering from other causes will gradually produce a wasteful as well as uncomfortable condition, if not cared for. A definite policy of pipe covering repair should be adhered to, not only to prevent waste of steam but for other reasons.

For instance, exposed steam pipes leading to the hammers in the forge shop will result in a considerable amount of water being carried into the hammer cylinders. It is well known that water is the arch enemy of lubrication in any cylinder and the steam hammer is no exception. Lack of covering in this case leads to poor lubrication, scored cylinders, blown out rod packing and excessive steam use by reason of these difficulties. Defective lubrication of the hammers usually results in the selection of a higher compounded cylinder oil for the hammers, with the inevitable result that these oils carry past the oil separators and find their way into the heating system, where damage is done by reason of reduced efficiency of heating surface and plugging up of traps all over the factory. Also some of this oil returns to the power plant where great difficulty is experienced in separating it from the return condensate. All of these troubles follow logically and with more or less certainty from a failure to cover steam piping and the losses resulting will run into substantial figures.

Studebaker has found it desirable to cover hammer steam lines with sponge-felted covering, secured in place by metal jackets to resist vibration. This scheme is quite effective. Experiments are now being with removable insulated covering which can be clamped around the hammer cylinders. This will reduce the warming up period, which requires a considerable amount of steam at present, and will make it more practicable to shut the hammers down between heats.

In many cases, it is not sufficient to cover the main steam lines because it will be found that serious heat losses will result from uncovered traps and small connections.

Figure 8 shows the method adopted of making removable covers for steam traps. These covers can be instantly lifted off for trap inspection and are effective in preventing radiation. It is entirely practical to cover outside steam lines which are exposed to weather as seen in Fig. 10, which shows how a 24-in. exhaust riser, separator and header, as well as a 200-lb. steam header, were treated for outdoor conditions. This covering consists of four inches of magnesia with water-proof jacket.

Study of Records Reveals Weak Points in Piping System

The table shows the activities of the piping maintenance department for a period of 35 days. The tickets from which this was compiled show classes of work in considerably greater detail than was possible in this tabulation. New work and changes in existing piping systems are included for the purpose of showing how much of this work was done by men on the company's payroll. It is the policy to carry on all of the routine maintenance work with company employes but unusual

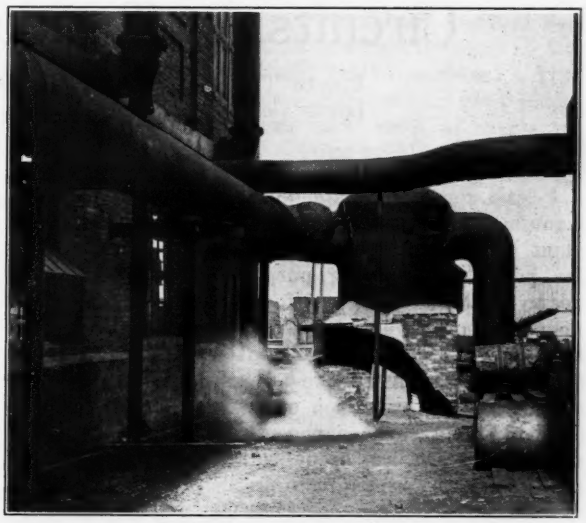


FIG. 10. METHOD OF COVERING OUTDOOR LINES

pieces of maintenance and most of the new work and changes are done by contract.

This tabulation indicates that too large a percentage of maintenance work was required on the return lines during this period and the reasons for this, as stated before, were dissolved oxygen and CO_2 in the return condensate. The next largest item of repair was the toilet fixtures. Practically all of the damage to toilets is either carelessness or willful misuse; most of this maintenance consisting of removal of rules and pencils lost from pockets of workmen, or from apparently willful damage to seats.

Next important of the items was the repairs to radiation. Most of this, as stated, consisted of accidental breakage of wall radiation by trucking operations. The unit heater has been a satisfactory solution for many such cases.

It will be further noted that during the period analyzed there was a total of 1203 different jobs requiring a total time of 2674 hr., or an average of 2.22 hr. per job. Of course the complexion of such an analysis

would change from time to time as many conditions are discovered and corrected but the tabulation given is fairly representative of the present work carried on by the maintenance steam fitters.

Note that the item of floor drains accounts for 5.9 per cent of the total maintenance hours. This was because all the drains from spray booths were provided with traps which served to interrupt the flow of lacquer deposit when cleaning the booths. This resulted in a continual necessity for cleaning out and, as soon as the traps were taken out, this maintenance was eliminated.

In order to make the reporting of piping system troubles more effective, a red tag system was developed to take the place of the repair and renewal work order. The red tag is perforated, one-half of it being supplied with a piece of wire for securing to the equipment needing repair. The foreman or workman discovering the fault fills out one-half of it with the department number, building number, the floor and the nature of the trouble. This half he mails to the maintenance department and secures the other half to the piece of apparatus. That portion of the tag may be removed only by a maintenance man when he comes to repair the fault.

The two halves of the tag are given the same serial number so that, after the maintenance man has made the repair, removed the tag and sent it to his foreman, it constitutes his report that the fault has been remedied. The filing of the incompleted tags in the office of the foreman constitutes a record of incompleted maintenance jobs. Of course, in case of emergency the telephone is used for making a report.

Prior to the time when a detailed study was made of all of the conditions mentioned above, the steam fitting department carried approximately 50 men for maintenance work only. It now carries the equivalent of about eight men, although, since the time when 50 men were required, the plant has almost doubled in size.

Circuits for Temporary Power Supply

PROPER TYPE OF CIRCUIT, GOOD MATERIAL AND WORKMANSHIP AND A LOT OF COMMON SENSE ARE NEEDED FOR THIS WORK. BY A. C. BARKER

BECAUSE OF changes in demand for product, or at least for increased manufactured facilities, many manufacturing concerns find that rearrangement of plant becomes necessary, which in turn calls for lines for power and lighting purposes, more or less temporary. At times, the cost for such lines seems greater than it should be and we whose duty it is to lay out temporary as well as permanent work, may well stop and determine whether we are using the same degree of efficiency in utilization of material and labor as is done by the factory management in their production processes, which has brought them the reputation of being the keenest manufacturers in the world.

OPEN VS. CONDUIT WIRING

Having located the proposed line and figured the size of feeders needed to serve the load, it then becomes necessary to decide upon the method of supporting those feeders. For many years, the prevailing custom was to run them cleated to the ceiling or to the bottom of the ceiling timbers, with turnbuckles at one end to maintain the tension on the line. This method had advantages and worked out satisfactorily for most cases but, due to factory ceilings becoming more and more congested, as time went on, the tendency was to place feeders, as well as branch circuits in conduit. Often this was from custom rather than from actual necessity. In the writer's experience, the open method, as a whole, has advantages over the conduit method, especially from the operating and maintenance points of view.

Run in the open, a feeder line is capable of withstanding temporary overload without damage to the feeders, if it is of standard wire and has slow burning insulation. The increased capacity of such a line, due to better ventilation afforded, is often a great help. In conduit lines, much trouble has been caused by waste oil leaking in from machinery overhead and sooner or later ruining the insulation of the feeders.

In these times of keen competition, when continuity of service means much and is essential in most plants, the open method may easily be inspected and actual condition and temperature noted; while on a conduit line, one moment you may be feeling perfectly secure and the next moment the line may be entirely out of commission. Actual cost of the open method is only a little more than half that of a conduit installation and in addition taps and alterations can be made on a live line with ease and safety where the open wiring is used; so that in most instances, the writer believes it to be the best on all counts.

A few days ago, I was present in one of our textile plants during a fire and was interested in observing just the effect on two different methods of construction of power lines, which happened to be directly under the room where the fire occurred. Several sprinkler heads had let go and tons of water were being poured directly onto a slow-burning, cleated-installation power line which was fully loaded but had no interruption whatsoever in service. The conduit line, also directly under the room where the fire was taking place, tripped out and nearly one-half day was required to dry out the conduit so that it was considered safe to use the line again.

REUSING MATERIAL

One item usually receiving consideration in temporary work, is the use which can be made of material after the temporary need is over; the open line construction gives the maximum possibility for salvage. Where rubber covered wire is used, the practice is to install it first on power lines at the higher voltage of 550 volts and when removed from the temporary power line, it is as a rule still fit for a lighting job at the lower, secondary voltage, thereby effecting a considerable saving.

It is important when considering the attachment of

a temporary line to a circuit capable of handling additional load, that it shall be checked up to make sure that this will be done without interfering with the original load on the circuit by putting too much stress on conductors, their insulation, their fusing or breaker capacity. On some lines, particularly of considerable length, attention should be paid to the voltage drop incurred since the torque of alternating-current motors varies with the square of the voltage and it is apparent that it is of importance to maintain full line voltage over the entire length of the line.

In temporary construction, more concern need be had regarding feeder lines than on branch circuits, as a crippled feeder line often interferes seriously with production and causes an interruption of an entire department, or may throw the whole plant out of balance. On a branch line, however, protected by smaller fuses, service is more easily restored and with less effect upon production.

Good Material and Workmanship Pay

On branch circuits, especially on temporary lines and under favorable conditions, it is often a temptation to use BX cable although such cable has been passing through a period of rather rough sea even on lighting circuits, to say nothing of using it for higher power voltages. We have, however, used considerable of this on three-phase, 220-volt small equipment and, in a few instances, on 550-volt circuits and have had no trouble whatever. We have taken precautions, especially where there has been any likelihood of mechanical injury, in which case the BX cable has been run through conduit. Although such cable can be used in some instances with good results, wires pulled into Greenfield cable seem more suitable for getting into difficult places. With power service, especially where there is likelihood of severe mechanical injury, rigid conduit is better. Many times, conditions are such that only a conduit job can be considered, whether the work is temporary or permanent. With the fittings on the market today for every conceivable place and the more recent threadless fittings, salvage becomes easier and the workman can do good work in less time. A few fundamental rules which should always be followed are, to make sure that the conduit is of sufficient size for the wire to be used, to use plenty of pull boxes, to keep runs short and make as few turns per run as possible and these of as large radius as possible. All wires of one circuit should be placed in the same conduit and the conduit always put in place before wires are pulled in, care being taken to ream all conduit ends and to locate the conduit away from hot steam pipes.

Many times, a line put in as temporary, perhaps for experimental work, becomes as time goes on, permanent equipment, contrary to the original plan. Experience has taught us that it is false economy to do even temporary work in other than first class manner as there is little difference between the cost of good work and hit-or-miss work. It has been proved many times that a good workman will do a good job as economically as a careless worker will do a poor job.

It should be remembered that an electrical job, even though well done, is not complete until the apparatus is properly grounded, a matter oftentimes overlooked. While electricians have formed the habit of looking out for themselves, the operator of some particular machine, not sensing his ever-present danger, may be taken unaware, if some defect shows up, with disastrous results.

Follow Underwriters' Rules and Use Common Sense

While the average plant man realizes the great task of drawing up the Underwriters' rules and regulations so that they will properly apply to all cases of electrical work, remarks are often heard that would indicate that rules as drawn would be of greater service, if they were more concise and arranged differently. The scope is very broad, the rules are rather dry reading and perhaps take too much of the atmosphere that, "if you keep away from the water you will not be drowned." When one stops to consider, however, how much is at stake in the way of life and property, how much abuse and rough handling electrical equipment gets in industrial plants, particularly with the large number of line starters now in use having remote control stations in almost every conceivable place, all these conditions call for so much care to be taken by the electrical department in the installations and maintenance of its work, that precautions should not be neglected. The average installation is a case of exercising good judgment, following the Underwriters' rules as nearly to the letter as possible and meeting problems out of the ordinary by following the spirit of the rules and working always to be well on the safe side. Exchange of ideas is always helpful and with this in mind, it is hoped that others will contribute their discussion of the subject.

Pipe Branch Diameters from a Steel Square

Yesterday, as I was contemplating the satisfactory condition of the world in general and my plant in particular, the head of a young engineer friend appeared at the door. "Are you good natured today?" he called. "Come in and find out," said I. "What's your easy problem today?"

"Well, our piping system's due for a general shake-up. I don't want to run any more new lines than I have to but I want to be sure to have enough steam capacity at all points. How will I know?" he explained.

"Tell me what you have now; then we'll see what's needed," said I. So he gave me these figures.

From the boilers an 8-in. main ran to the engine room, with a 1½-in. line taken off for boiler-room needs. A 6-in. line supplied the engine, and a 3-in. line had to be run to the factory for dry-house and process steam supply. What size main could be supplied for heating and other work?

Now this could easily be figured as follows, capacity being proportional to the square of the diameter:

$$8^2 = 64;\ 1\tfrac{1}{2}^2 = 2.25;\ 6^2 = 36;\ 3^2 = 9$$

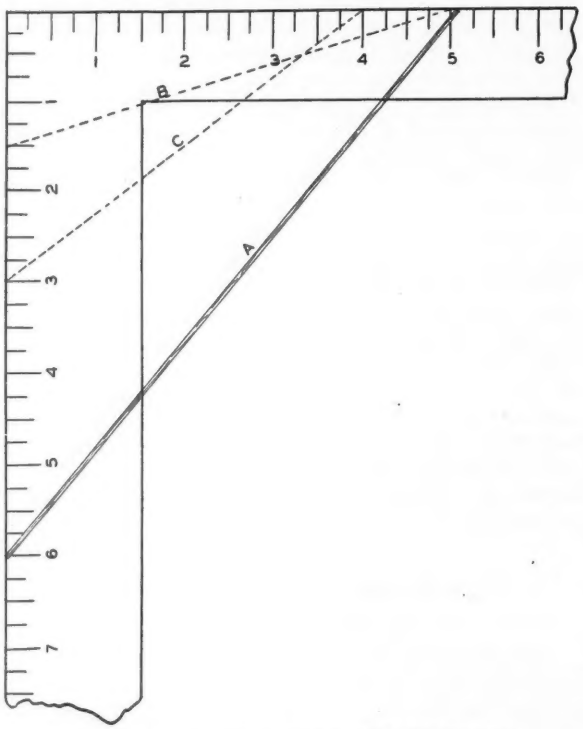
$$2.25 + 36 + 9 = 47.25 \text{ and } 64 - 47.25 = 16.75$$

Square root of this is 4.08 or a 4-in. line could be supplied.

"You can do it all on a steel square though without figures," said I. "How come?" he asked. So I showed him the trick.

Cut a splinter of thin wood to a length the diameter of the largest pipe, in this case 8 in. Put one end at the 6-in. mark on a steel square and bridge the angle. The other end will fall on the diameter of pipe which can still be supplied. In this case, a $5\frac{1}{16}$-in. (see A in sketch) pipe could be supplied besides the 6-in. to the engine.

Next cut a splinter $5\frac{1}{16}$ in. long. Put one end at the $1\frac{1}{2}$-in. mark, for the boiler-room branch, on the square and bridge the angle, as at B. The end falls on the 5-in. mark, or a 5-in. pipe can still be supplied. Cut the



STEEL SQUARE TO FIGURE PIPE BRANCHES

splinter to 5 in. long and place one end on the 3-in. mark, as a 3-in. pipe is to be run to the factory. Bridging the angle, as at C, the end comes to the 4-in. mark, so a 4-in. pipe could be supplied for heating and other use. Which is the same result as from figuring it out.

"That's all right," said the boy friend, "but how did you get that square of $1\frac{1}{2}$ so quick?" "Why," said I, "you just multiply the next higher whole number, 2, by the next lower number, 1, and add $\frac{1}{4}$. See—$2 \times 1 = 2$; $2 + \frac{1}{4} = 2\frac{1}{4}$, the square of $1\frac{1}{2}$. That's true for any number which has $\frac{1}{2}$ hitched to it."

"As to this stick and square method, you can use it either way. If you want a pipe to supply a 4-in. and a 6-in., find how long a stick reaches from the 4-in. mark on one leg to the 6-in. mark on the other. That will be the needed diameter of the supply pipe. It will be about 7.21 in. Of course, you would use an 8-in. pipe.

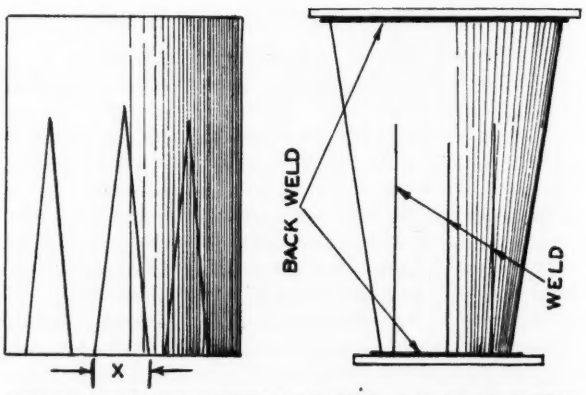
Indianapolis, Ind. J. F. HOBART.

ELECTRICAL STORAGE batteries for peak load service are usually limited to those systems which have direct-current distribution.

Welded Reducing Fitting

CAST-IRON fittings are being discarded in favor of bends, angles and the like, built up with the oxy-acetylene torch, a process especially common on low-pressure water lines. Patterns should be developed in the drafting room so that the welder may know exactly what to do. In one case, we found it necessary to make a reducer quickly and this was done from a piece of pipe, the reduction being from 12 to 8 in.

A piece of 12-in. pipe of the required length was taken. Ordinarily, this should be the length of a standard cast-iron reducer. The difference in circumference between the 12-in. and 8-in. circles was determined and divided by 8; more slots could have been used, had it been desired to get more nearly to a true circle. The piece of 12-in. pipe was then slotted at 8 intervals, the width of the slots being $\frac{1}{8}$ of the predetermined difference between circumferences and the



METHOD OF CONSTRUCTION OF CONE SHAPED REDUCER

slots being run back to a point at about $\frac{2}{3}$ the distance from the end of the pipe section. After the slots were cut, the pipe was heated and the slots closed by bending the sections toward the center. Flanges were slipped over the ends, slot edges welded together and the flanges back welded to the ends of the reducer.

These flanges may be made out of scrap plate, drilled to conventional spacing for the bolt holes but the welder must exercise due care in lining up holes in the flanges on the two ends and seeing that the flanges are parallel and perpendicular to the axis of the pipe.

Lincoln, N. H. A. P. NUTTER.

Removing Stretch from a Belt

THE FOLLOWING original method for making a new leather belt stretchless is at least novel. The information was given to me by a man who stated that he had tried out the kink with satisfactory results.

A new leather belt is rolled up, placed in a tub of cold water and allowed to soak for several hours. It is then taken out of the water and run through a set of iron rollers such as is used by tinsmiths, the rolls being set close enough together to exert considerable pressure on the belt as it passes between them.

After the entire belt has been passed through the rollers it is possible that it will have developed a slight curve, to remove the curve and render the belt straight again, also to complete the process of removing the

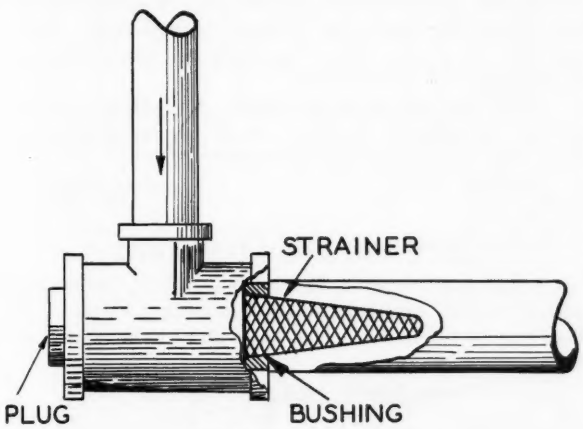
stretch, give the belt a half turn and, after tightening the rollers a little closer together, again pass the belt through them. The belt is then allowed to dry out and put into use, a liberal application of a first class, fairly thin belt dressing being made on the belt surface.

My information stated that a new belt so treated gave excellent service from the start without repeated shortening and relacing as with an ordinary unstretched leather belt. Furthermore, a belt which has developed a serious curve along its length can be straightened, whether the belt be new or old, by passing it through a set of rollers as described; at least so I was informed.

Toronto, Can. JAMES E. NOBLE.

Strainer for Sediment

FOR CORE SUCKER pumps, brine sprays and other places where sediment finds its way into liquids that should be kept clean, an effective strainer is made in the



STRAINER IN PLACE

shape shown. It should be placed in a line with a tee having one end plugged. The run of the tee should be large, with the outlet end bushed down, so that the strainer can be removed for cleaning. The strainer is to be of as fine mesh as required and in a long cone to give greater surface. It should be a snug fit into the tee opening to prevent displacement.

Kansas City, Kansas. J. F. STALEY.

Acid Condition Exists in Engine Crankcase

ALWAYS AN ACID condition is present in an engine crankcase, from acids in the lubricating oil, in the diluents in the oil and in the vapors escaping from the crankcase. Some of the acids (such as sulphurous acid) are more soluble in water than in oil and some of them are corrosive.

Organic acidity, due to the presence of naphthenic acids, has been found in crankcase oil, in diluents and in condensed water vapor, the organic and mineral acidity, as indicated by the neutralization value of the oil, apparently reaching a maximum after the oil has been in service for several hundred hours of operation.

Since greatest damage from the existence of acid vapors occurs when water (resulting from condensation) is present in the bottom of the crankcase, complete draining and thorough flushing of the crankcase at regular intervals—more often in winter than in summer, since cold weather is the time when condensation of the water vapors is most likely to take place, is recommended.

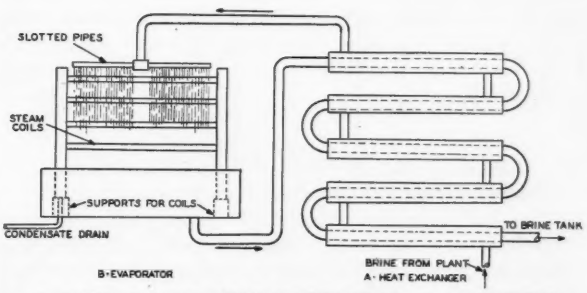
Denver, Colo. H. L. KAUFFMAN.

Moisture Evaporator to Strengthen Brine in Spray System

IN SOME plants it is not only convenient but safer to use calcium chloride for brine than common salt. Where all or part of the system is a spray system instead of coils, the brine increases in quantity and decreases in strength against freezing, hence it becomes necessary either to strengthen the brine with more calcium or to evaporate the surplus moisture, in order to bring the brine back to a strength where it will stand the required temperature.

The evaporator shown is inexpensive, yet effective and no trouble to operate. Outer pipes of a double pipe exchanger are connected into the brine return line from the main system to the evaporator, the brine from the evaporator being fed through the inner pipes of the exchanger, giving a counter-current effect and at the same time almost a perfect heat exchange.

Steam coils, six pipes high, of 2-in. pipe welded to manifolds are supplied with exhaust steam and supported in a pan as shown at B. Brine from the heat exchanger is fed through slotted pipes over these coils,



A. DOUBLE PIPE HEAT EXCHANGER. B. MOISTURE EVAPORATOR

then to the exchanger and back to the brine tank. Where exhaust steam is available, cost of operation is practically nothing and labor is about the same.

Kansas City, Kan. J. F. STALEY.

PERFORMANCE of a pumping engine is usually expressed as the duty per 1000 lb. of steam, or the duty per 1,000,000 B.t.u. Because of the wide range of steam pressures now in use, 1000 lb. of steam is hardly a measure of the heat supplied the engine, so that the duty per 1,000,000 B.t.u. is generally preferred.

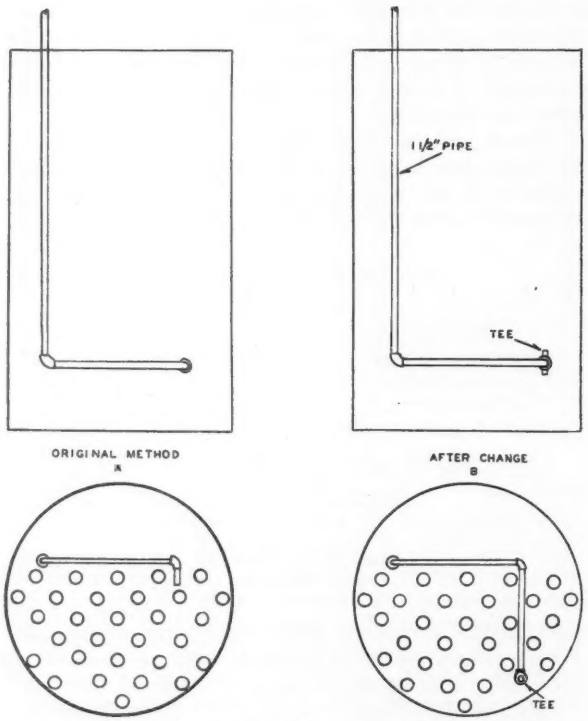
Duty in foot-pounds of work done per 1000 lb. of steam is found by multiplying the number of pounds of water pumped by the average total dynamic head in feet and dividing the product by the weight of steam supplied expressed in thousands of pounds. Duty per 1,000,000 B.t.u. is found by multiplying the same two quantities and dividing the product by the B.t.u. supplied expressed in millions.

Piping Change Overcomes Scale Formation

DISTRIBUTING the incoming feedwater instead of directing the stream at a localized point in the boiler end of which a tee was connected, and by placing the vertical pipe in the middle of the boiler as shown at B so that it extended down to about one inch below the center row of tubes with the tee pointed lengthwise of the boiler, the feed was properly distributed. Since making the change, there has been no trouble due to scale formation on the tubes.

With the former arrangement, the water was admitted too near the surface. With the latter arrangement, the steam generated is dryer.

Seymour, Conn. CHARLES MEHR.



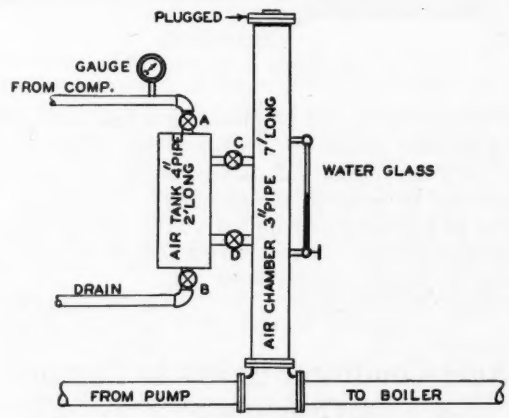
TEE AT BOTTOM OF BOILER DISTRIBUTES INCOMING FEEDWATER, AVOIDING LOCAL IMPINGEMENT AND SCALE FORMATION

Surge Action Overcome

AFTER INSTALLING a 12 and 8 by 12-in. boiler feed pump, we had considerable trouble from a surge in the feed line to the boiler. The water end of the pump was solved a problem of scale formation that bothered us for a long time.

We have three return tubular boilers which originally had their feed lines piped as shown at A in the illustration. The feed pipe was run about three-quarters of the length of the boiler, then directed downward through an elbow and nipple. The concentrated discharge against the boiler shell and tubes directly below caused hard scale to form on those parts to such an extent that every three months a man was required to cut the scale off with hammer and chisel.

By replacing the nipple with a piece of pipe, at the



AIR CUSHIONING ACCOMPLISHED BY LARGE VERTICAL PIPE

equipped with a large air chamber but this seemed to give little aid. At times, the surge and vibration were serious.

First, we thought to install an air chamber on the feed line and keep it charged with air by the air compressor but finally installed it on the discharge line from the pump at a point just before the water entered the oil and grease extractor as illustrated. The air chamber was charged by the compressor once a day, about six o'clock in the morning.

This air chamber eliminated our trouble. To operate it, we first start the air compressor, then open valves A

and B on air tank. When the water has drained from the air tank, valve B is closed. When gage shows 100 lb., valve A is closed and valves C and D are opened. Bubbles rising in the water glass will indicate that air is flowing into the air chamber. When bubbles cease rising, valves C and D should be closed. This operation has to be repeated three times in order to get sufficient air in the air chamber. When the air chamber is sufficiently charged, the water in the glass will disappear from sight. I have used as much as 100 lb. pressure but the amount of pressure appears to be immaterial.

Brockton, Mass. COLEMAN WINCHESTER.

Stoker Ram Balks

ON ONE JOB, I was called to see whether I could discover why the ram of the stoker would operate all right for two or three days and then take about a half

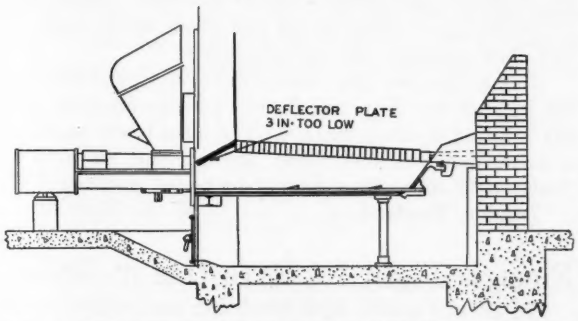


FIG. 1. THE DEFLECTOR PLATE AT THE FRONT OF THE RETORT WAS SET TOO LOW

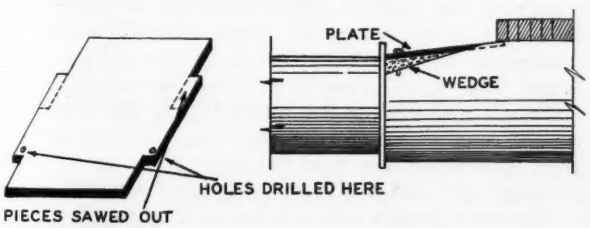


FIG. 2

FIG. 3

FIG. 2. THE DEFLECTOR WAS HUNG ON THE SIDES OF THE RETORT BY LUGS WHICH BUTTED AGAINST THE TUYERES

FIG. 3. WEDGING UP THE DEFLECTOR PLATE CURED THE TROUBLE

stroke and stick. That meant digging coal out of the hopper and ahead of the ram. Then maybe the ram would take a couple of strokes and stall again. It stalled eight times in 4 hr. the afternoon before I was called.

When I arrived, the fire was out but it was pretty warm in that furnace as the bricks were still red hot. We got the retort dug out so as to see whether the pusher rod was all right. I have seen the rear end pusher block slip off the rod and get wedged in under the rod causing it to bind in guide block and buckle up. But this part was all right so we kept digging.

At the front, the deflector plate was found 3 in. too low, next to the ram, leaving only 6 in. clearance vertically for the coal to get through. This was a job lot retort, cast in a local foundry and the holes in the face of the retort, where the ram case was fastened on could not be changed. The center pier, between the fire doors, was built on top of this plate and, in this case, was made of plastic so that we could cut enough of it away to get to the plate. Figure 2 gives an idea of what the cover plate looked like. It was not bolted to the retort as is usually the case but was just hung on by the projections on the sides, these side lugs coming against the tuyere blocks to hold it from slipping endwise.

We raised the deflector plate 3 in. and blocked it with some old iron wedges we found. Holes were drilled in the lugs as shown in Fig. 3 and in the wedges and tapped for $\frac{3}{8}$-in. cap screws so that the wedges could not slip out. The pier was rebuilt and when the stoker started the trouble was gone.

Minneapolis, Minn. FRED S. RUTLEDGE.

Watch Glass Indications

UNLESS SOMEONE takes the trouble to enlighten him, the average man starting work in a power plant fails to learn many useful bits of information. One of these is how to read the story told by the water-gage glass on the steam boiler. The glass will serve its purpose to show water level in the boiler so long as all connections are in proper condition.

When the boiler is working, the water in the glass should fluctuate up and down slightly and continuously. If it does not, that can be taken as certain indication that something in connection with the outfit is not right. The thing to do is to blow out the glass and water column and then note whether, after resetting the valves, the water in the glass fluctuates. If it does not, the boiler should be taken out of service and all connections, pipes, valves and fittings examined to locate and remove the trouble, which is likely to be a partly closed passage in some connection.

Toronto, Canada. JOHN THORN.

Trouble With Motor Starters

ON 50-HP. DIRECT-current motor two armatures failed in quite a short time. This motor was subjected to frequent starting and stopping. A 50-hp. controller was used for starting but since this was considered too small it was replaced by a 100-hp. controller of similar type.

After the larger controller was fitted, there was no more trouble, the trouble having evidently been caused by the controller being too small. Where a motor is being started and stopped continually the size of the starter or controller should always be liberal, owing to the greater work imposed on the starter. With auto transformer motor starters as used for a.c. motors, it should be remembered that these are not designed to be brought into operation more than five or six times per hr. If used more often than this the starter will overheat, and, possibly burn out. There is an insufficient volume of oil in the starter tank to help the starter cool if used too frequently.

London, England. W. E. WARNER.

MARCH SALES of mechanical stokers, as reported to the Department of Commerce by the ten leading manufacturers in the industry, totaled 85 with 27,951 hp., as compared with 73 of 22,648 hp. in February and 117 of 42,432 hp. in March, 1929.

Emulsification Causes Oil in Distilled-Water Ice

DURING THE SUMMER, when our ice machines are run full speed 24 hr. a day, the water in the reboiler and storage tank of our plant would change to a white gray color and the ice would have a red streak through the center which indicated presence of oil. All storage tanks and the reboiler and distilled water line were steamed out but the condition was not improved. Then the cylinder oil was changed but this also did no good.

Our trouble was found to be due to the high speed of the ice machines which resulted in the steam condenser losing its vacuum, thus increasing the heat and pressure to such an extent that the cylinder oil was emulsified, therefore could not be separated out until the water was frozen. It was found that, by increasing the cooling water supply, the pressure in the steam condenser could be lowered and our trouble overcome.

Denver, Colo. L. E. BOWDEN.

Neverslip Screwdriver

ANY ORDINARY screwdriver blade can be converted into one that will never slip. Such a blade will hold in any screw slot even when the slot is more or less broken or the edges somewhat rounded.

ROUGHENED SURFACES OF SCREWDRIVER PREVENT SLIPPAGE

Draw the temper from the end of the blade and, when the blade is cold, place it flat on any solid metal base. Using a sharp cold chisel, make diagonal cuts about ¼ in. long and $\frac{3}{32}$ in. apart as shown in the illustration. In cutting the other side, rest the blade on a piece of dry hard wood or a block of soft metal. Now reharden and temper the blade.

Screwdrivers provided with roughened faces such as described are obtainable in the market in some localities.

Toronto, Canada. JAMES ELLETHORN.

Collapsed Tank Restored

OCCASIONALLY tanks or other cylindrical vessels in the power plant collapse. They are "sucked in," owing to the creation of a partial vacuum. A regulating valve may have failed or an operator may have neglected to take proper precautions as to manipulating his valves.

Often such tanks can be easily restored and rendered as useful as ever, even though the collapse has been so great that the top and bottom of the tank touch. To restore the collapse quickly and effectively requires merely the utilization of water pressure to reëxpand it. Probably a single stage centrifugal pump may not give sufficiently high pressure for the purpose but a multi-stage centrifugal pump may do the trick.

Better still, an ordinary steam or reciprocating pump may be used to pump water into the collapsed tank, causing it gradually to assume its original shape. If the tank is riveted, some calking is usually necessary or if the leaks are unusually bad the tank may have to be welded at points of leakage. The tank can then be used as before the collapse. Furthermore, it may be reënforced, if considered necessary, so as to prevent repetition of collapse.

Newark, N. J. W. F. SCHAPHORST.

Parallel Operation of Alternators

WHEN TWO ALTERNATORS are working in parallel, it is important that the magnetic flux round the armatures of both machines is uniform.

If there is a fault on one of the field coils or the air gaps round the armature are unequal, the value of the flux passing through the armature as it rotates will vary continually.

This will result in a variation of the armature current, which in turn will result in a circulating current passing between the two paralleled machines which does not reach the external circuit. In these cases, the voltage wave of each machine should be found; this is done by connecting a lamp across one phase of the machine and then running the machine slowly.

If the magnetic flux around the armature is unequal, the light of the lamp will fluctuate in synchronism with the rotation of the armature. The most likely causes of a nonuniform magnetic flux are unequal air gaps or faulty field coils; these should be tested and remedied.

London, England. W. E. WARNER.

Electric Light for Safe Use in Boilers

TO SUPPLY a safe light for boiler use without going to the trouble of building a transformer, secure a 5-v. lamp and socket and use four ordinary dry cells for supplying the current. Such cells can be bought in bulk at a fairly low price. Four cells will supply a continuous current for a 5-v. lamp for quite a few hours. The lamp to use is of the type used in magic lanterns. These lamps are about 1¼ in. dia. and give a light equal to a 40-w. tungsten lamp. I know of one such lamp which was used for nearly 2 yr. as a boiler cleaning light and is still in fairly good condition.

The main trouble with this device is to get something besides a brass socket. Such a socket can be made safe, however, with rubber tape—not friction tape—wound all over tightly and several plies thick. Of course, the rubber tape should cover the joint between the socket and the lamp base.

A safe and non-kinking extension cord can be made by pulling the extension wire through a ⅜-in. soft rubber tube, using a rubber composition socket for the lamp and a wire guard to save lamp breakage. I know of such a rubber tube covered extension which has been in use nearly 2 yr.; it has had a lot of pulling over sharp and near sharp edges and rough parts and is still in fair condition. No ordinary or sane treatment will cause a dangerous break in the rubber tube but, even after the tube is injured, the extension wire covering must also be broken to cause trouble.

Toronto, Canada. JAMES E. NOBLE.

MAXIMUM BOILER EFFICIENCY occurs at the load where the sum of constant losses due to radiation and variable losses due to flue gas and combustible in the ash bears a minimum ratio to the total heat supplied to the boiler.

Questions and Answers

Test for Oil in Boiler Water

IS THERE ANY chemical or other method that can be used on a sample of boiler or feedwater in order to determine presence of small particles of oil?

F. D.

A. In order to test water for presence of oil, the sample of water should be first cooled, then shaken vigorously with one-fifth of its volume of gasoline or of ether in the type of separating-funnel shown in illustration. The liquid is then allowed to stand 15 min. in the funnel, supported in an upright position in a retort

SEPARATING FUNNEL USED IN OIL TEST FOR DETERMINING PRESENCE OF OIL IN WATER

stand, the water being run off through the separating cock and the gasoline or ether solution which floated on the water and contained all the oil and fat, drained into a porcelain basin. This oily portion is placed upon a hot water bath but no lighted lamp should be kept beneath it, since gasoline or ether vapor is very inflammable and all open flames in the room must be extinguished. The gasoline or ether evaporates quickly and leaves the oily or fatty matter as a residue in the basin.

If desired, this test can be made quantitative in character by using 250 c.c. of the water for the test and, toward the end of the evaporation, transferring the solution of the fat to a tarred platinum basin. The large porcelain basin and the separating funnel must in this case be rinsed out with the same spirit and the rinsings added to the solution in the platinum basin. The oily residue in this, after heating for some time at 212 deg. F., is finally weighed.

To distinguish between animal, vegetable and mineral oils, the residue in the basin should be heated on the water bath with a strong solution of caustic potash. Animal and vegetable oils saponify, that is, yield a soap under such treatment, while mineral oils remain unaltered.

Presence of oily and fatty matter in boiler scale can be detected by heating the sample of scale to redness in the platinum basin. If charring occurs or if a disagreeable odor be noticed, some organic fatty compounds are probably present. Fats and oils of animal or vegetable origin are more dangerous lubricants for engines than hydrocarbon oils of the paraffin class, since the former contain oxygen and yield organic acids when decomposed at the high temperature occurring in the boiler.

Holly Steam Loop

HOW DOES the Holly steam loop work and what is the automatic valve on such a system and how does it operate? W. H.

A. In the Holly loop system, all condensation is collected in a common receiver placed at the lowest point to be drained. A large cylindrical tank, located at a considerable height above the boiler room, is connected with the feedwater heater through a reducing valve. A riser connects the receiver with this tank and a drop leg leads from the tank to a point in the boiler below the lowest water level. In starting up, a valve in the bottom of the drop leg is opened to the atmosphere until there is a continuous flow through this opening, of steam and water entrainment from the receiver. The valve is then closed and, by bleeding the upper tank through a reducing valve into the feedwater heater, a pressure is maintained in the upper tank or discharge chamber sufficiently below that of the steam in the receiver, to permit of a flow of steam and water slugs from the receiver through the riser into the discharge tank. The steam separates from the water and passes through the reducing valve into the heater, while the water collects in the bottom of the discharge tank and in the drop leg until the head of the steam and water is sufficient to overcome the resistance of the check valve in the boiler. The process is automatic and continuous so long as the plant is in operation.

Steam Pump Operation

WHAT are the principal reasons for incorrect operation of steam pumps in pumping water?

L. N.

A. Some reasons for incorrect steam pump action are: Incorrectly set valves; leaky stuffing box; over tight piston packing; too small or too long suction pipe; pumping hot water under suction head; too high pump speed; improper seating of suction or discharge valves; use of too heavy valve springs; broken valve spring.

ANNUAL LOAD FACTOR of a plant is the ratio of the kilowatts generated to the maximum demand of the year multiplied by 8760, the total hours per year.

Editorial Comment

Air Conditioning and Human Nature

According to recent reports, every window in the lower sixteen stories of one of the newest of the tall buildings in a large city is to be fastened down. All air is to be introduced to the rooms at the proper temperature, cleanliness and humidity through an air conditioning system designed for this work when the building was erected a few months ago.

It would be extremely interesting to observe over a considerable period the reactions of the people who are to work seven or eight hours a day in this building with all the windows securely fastened. We can foresee for those workers and their superiors a great deal of trouble of various kinds.

Fortunately, in this particular case, the sixteen floors in question are used by one organization, a large banking house. Thus a good deal of the friction that will undoubtedly arise can be eliminated easily.

The troubles these workers will have will be due almost entirely to mental or psychological causes. For years we have been so accustomed to thinking that fresh air from outside, coming through an open window, has a particular virtue of its own, that engineers may have difficulty in overcoming that feeling. Much evidence has been presented, of course, to show that there is a "vitality" in ordinary air that is not possessed by air treated and passed through fans and metal ducts. Many engineers admit this condition, accounted for by a deionization of the air by the large amounts of metal over which it passes at considerable velocity in an air conditioning system. Many experiments have been made with the idea of revitalizing conditioned air with ozone and several commercial devices for this purpose are in successful use. In short, although everything is not yet perfect, the air-conditioning engineer is able to produce "live" air at proper temperature and humidity for comfort and health and with the additional advantage that it is free of dirt and bacteria, a condition that is surely not met by "natural" air in our large cities.

It seems to us that the problem of the air conditioning engineer at present is more involved with human nature and its various prejudices than with engineering details. This condition, of course, holds true in many other fields. If the human race could only forget its prejudices and its politicians long enough to use to the fullest extent the knowledge that science can even now make available (a mere scratching of the scientific surface) the race could build itself a civilization so far superior to others in material comfort that it would look upon its present condition as utter barbarism.

So it is with air conditioning, only a small part of the total engineering activity. Already architects and building engineers are looking ahead to a type of building entirely different from those we have today. This building may even have no windows at all. It is possible that the various lamps producing ultra-violet rays may be used in the not distant future to replace sunlight in buildings and that the atmosphere in a room without windows may be made better, more comfortable, cleaner and more healthful than even the best conditions outdoors. Much of the pure science needed for this development is available now. The engineer must begin at once to deal with the human side of the problem. And he must take care that the truly honest engineering is not perverted by the charlatan. But, if he does these things, the applications of air conditioning promise to lead to living and working conditions far superior to anything the general public can visualize today. The engineer should do a great deal now in the way of education to remove the prejudices that will undoubtedly obstruct the new order of things which is rapidly approaching.

Definition and Accurate Power Costs Needed for Plant Comparison

In an excellent study of Public Utility Economics just issued by the Institute for Research in Land Economics and Public Utilities, Chicago, written by E. Orth Malott and entitled "Forces Affecting Municipally Owned Electric Plants in Wisconsin," emphasis is laid on the difficulty of obtaining exact cost data from municipal and small power plants. Beneficial effect of commission control, which has been in evidence since such establishment, has been secured through the requirements of exact comparative cost data.

Demands of stockholders in large utility organizations require the setting up of adequate means to secure accurate costs which can be analyzed and properly allocated in order not only to know the unit costs but to have bases for their reduction. Rarely is civic consciousness strong enough in large cities to create a like demand for such cost data on the part of the citizenry. It is principally for this reason that municipal ownership usually lapses in large municipalities.

"Only one municipal plant in Wisconsin was in a city as large as 17,000 in 1930 and 93.1 per cent were in cities and villages under 5000 in population" is asserted in the monograph. The individual in a large city, who is not directly and earnestly concerned with power for municipal purposes, usually realizes the difficulties accompanying attacks of any kind upon the authorities who have the management of such power plants in charge and he appreciates the expenditure of time and energy that would be required of him, hence assumes a laissez faire attitude. In small cities, on the contrary, citizens usually develop a keen sense of ownership and are willing to express themselves forcibly on questions involving the management of their municipality.

Difficulty of comparison of municipally owned power plants and public utilities exists largely because of the diametrically opposite standpoints regarding property valuations. With municipal plants, the desire is to write off the cost of equipment from earnings as quickly

as possible, while with public utilities there appears to be a desire to appreciate the valuation wherever possible, interest on such increased valuation being charged, which raises the production cost, hence permits maintaining a high return on actual investment while the apparent return may appear to be normal or low.

Difficulty with valuations is illustrated by an investigation made a few years ago of the Waterloo, Wis., Water and Light plant which was purchased for $8500 but which was entered on the books of the Wisconsin Railroad Rate Commission, which controls power rates in Wisconsin, at a valuation of $13,750. According to the books of the municipality, the gross income per year from the sale of steam heat alone averaged $6112.80 for the years 1925 to 1927 inclusive.

Another difference of opinion rests in construction charges. Particularly in the case of Diesel plants which may be built in a short time and in some cases by concerns which assume all such charges, this question complicates comparison.

Is it not desirable, therefore, to reduce the interest on investment as the cost is written off the books by earnings? And is it not best to segregate these and the construction costs from the other operating costs but to establish accurate and well defined methods of assembling such costs?

Merchandizing power energy differs widely with the two power organizations. With the privately owned public utility it is of major importance and adds much to the overhead expense; with the municipal plant it is of little importance. In this connection the service rendered by public utilities in educating the public to greater use of electric power, hence to greater employment of labor-saving devices, cannot be overlooked.

Comparing municipal plants of small cities with company plants of corresponding size, we find the labor and supervision cost of the latter to be higher, if we include the proper prorated cost of salaries of officers of the chain of controlling organizations in some cases as many as four companies, all of which are not only officered but are expected to pay dividends to stockholders. On the other hand, superior organization, supervision and standardization, usually found in private organizations which control a number of power plants, favorably affect the complexion of the balance sheet in the books of the concern.

Both municipally and privately owned public utility plants have their places. Adequate as well as accurate and well defined costs aid in establishing these fields. Nothing is gained by obscuring facts concerning these two valuable agencies of contemporary industry.

Power Consumption as an Index of Prosperity

With electricity playing such an important and universal part in our domestic, industrial and rural activities, it is but natural to look for some connection between power consumed and industrial prosperity.

This dependence of power consumption on prosperity was well established last fall after the stock market break. During the latter part of the year, power consumption fell below the figure of normal growth which might have been expected from past experience.

By dividing the country into broad economic regions and analyzing the power figures, definite trends are revealed. Regions devoted primarily to agriculture showed a smaller decrease in power consumption than the centers of commerce and industry where the greatest activity was recorded previous to the slump.

Along the north Atlantic seaboard and in New England, business continued at about the same level as during the latter part of the season. In the south, some slight decrease was noted while in the middle west, the Allegheny and the Missouri River districts, a sharp decline in industrial activity took place, particularly in the automotive and heavy manufacturing centers.

The Rocky Mountain regions showed a drop in power consumption reflecting the curtailment in smelting and mining. California and Oregon showed little difference from conditions last year but the severe drought in Washington forced curtailment of industry in several centers where steam standby power was unavailable.

Figures of power consumption are easily tabulated and accessible. They have not the advantage of long time forecasts but they are becoming of increasing importance for indicating the trend of business and serving as a measure of the prosperity of the country as a whole or of certain sections of the country to which they apply.

Hydraulic Laboratory Bill Meets with Favor in Congress

Passage, by both the House and Senate, of a bill authorizing the expenditure of $350,000 for the construction and installation on the present site of the Bureau of Standards, Washington, D. C., of a hydraulic laboratory building with such equipment and appurtenances as may be necessary, is a measure of legislation which is welcomed by the engineers of the country. The bill now goes to conference and will probably be enacted into law within a few weeks.

How far the laboratory workers will be permitted to go into the practical application of hydraulic equipment has not been definitely made known but it may be assumed that the policies governing the conduct of the Bureau of Standards and the Bureau of Mines laboratories will be followed closely. If so, engineers and manufacturers having hydraulic problems of a fundamental nature to investigate can secure the cooperation of the specialists in the hydraulic laboratory. In other lines of research, this service has been of inestimable value as it has made available to industry facts and figures upon which to develop commercial equipment.

In the past, considerable work of the sort that should rightfully be done by the Government has been financed by voluntary subscriptions from public-spirited engineers and manufacturing concerns, many of whom were not even remotely concerned financially with the outcome of the experiments but who have made their contributions to accumulate professional information through engineering societies and special committees, such as the Engineering Foundation, which carried through the tests on the Stevenson Creek Dam, built and tested at a cost of over $100,000.

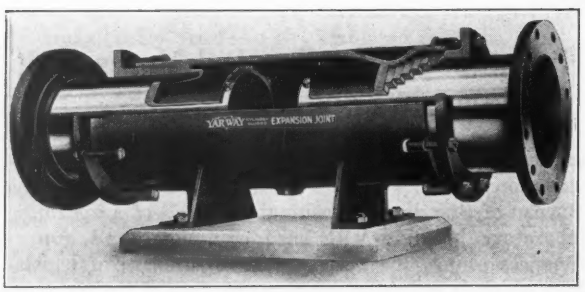
Preservation of safety and conservation of our natural resources are two fundamental functions of our government and the workers in the National Hydraulic Laboratory can contribute toward both.

Power Plant Engineering Developments and News

Cylinder Guided Expansion Joints

YARWAY Cylinder Guided Expansion Joint, described briefly in the January 1 issue of Power Plant Engineering, shown in section herewith. This is supplied in the double type with base, as illustrated, also in single type with or without base.

The sliding sleeve is designed to be well away from the inside bottom of the body dirt pocket. The sleeve



SECTIONED VIEW OF DOUBLE TYPE CYLINDER GUIDED EXPANSION JOINT

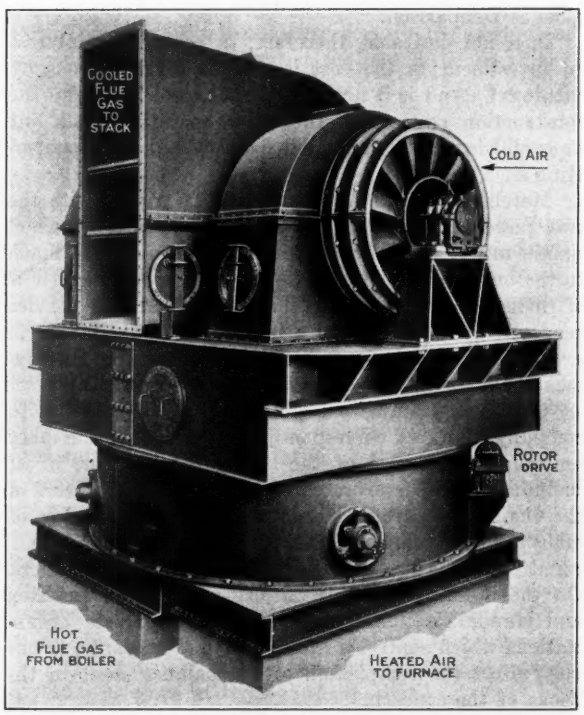
is of cylinder-guided type of chromium plated steel. Cylinder guide and stuffing box are integral to insure perfect alinement. The body is designed to be strong and light and the entire joint is made to be easily accessible for adjusting the gland and repacking.

An important feature of the design is that the entire joint is smaller in diameter than the pipe flange itself. It has internal limit stops, large deep stuffing-box and service outlets and special bases to suit requirements. It is made standard or extra heavy for saturated and superheated steam and hot liquids. It is made in sizes from 2½ to 24 in by Yarnall-Waring Co., 102 E. Merimaid Lane, Chestnut Hill, Philadelphia, Pa.

Changes in Integral-Fan Type Ljungstrom Preheater

LJUNGSTROM Preheaters, integral-fan type of 10-ft. and larger diameters, are now built with a low rectangular upper chamber, having underneath a circular flange which bolts to the rotor housing. The forced-draft and induced-draft fans, which in previous design were located inside a large upper chamber, are now mounted on top and encased in scroll housings, as shown in the illustration.

Adoption of a scroll in conection with the axial fan wheel results in a considerable improvement in the fan performance, it is claimed. The scroll increases the capacity of a fan of given diameter approximately 20 per cent, it is stated, and the horsepower required for equal capacities is decreased by from 15 to 20 per cent.



NEW CONSTRUCTION OF LJUNGSTROM PREHEATER, SHOWING FAN SCROLLS AND SUPPORTS

The rectangular housing carries the rotor suspension bearing in its division wall and also has heavily reinforced ledges on two sides which act as supports for the entire weight of the preheater, the rotor housing and the lower connecting plate being suspended from this upper housing. The new arrangement brings the level of support for the entire preheater close to that at which the fan driving motor should be mounted. Instead of supporting this motor on a cast-iron bracket attached to the preheater shell, as in the smaller sizes, it is now mounted directly on the boiler room support structures.

The forced-draft fan scroll discharges downward into the rectangular housing which acts as a plenum chamber over the rotor. The induced-draft fan scroll is mounted immediately over the dividing wall between the air and gas sides and the adjacent inlet box provides for

drawing the gas from the rectangular housing over the rotor to the fan, from which it is discharged into the scroll.

The outlet of the gas fan scroll can be vertical, horizontal or 45-deg. angular upward in either direction. The forced-draft and induced-draft fans are mounted on the same shaft, which extends through the scrolls and inlet boxes from side to side and is carried on suitable heavy-duty SKF roller bearings, mounted in a substantial bearing housing.

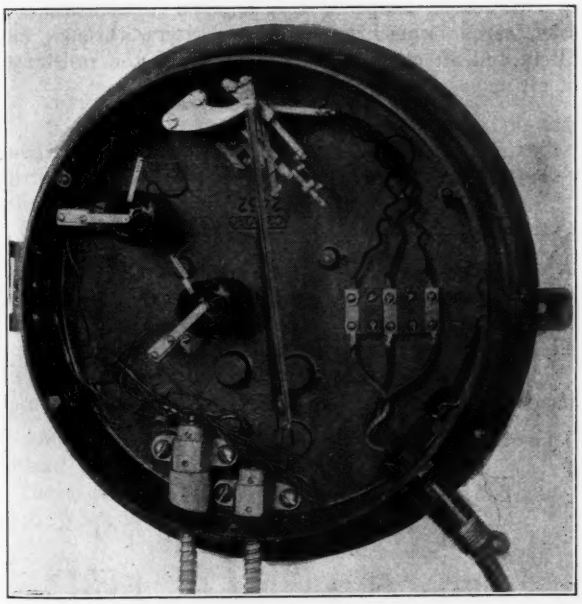
The bearing housings are fitted with large reservoirs in which approximately 4 gal. of oil are stored. Circulation over the bearings is effected by a ring oiling system, the same as used on sleeve bearings.

Heat reaching the bearings from the fan shaft is removed by the circulation of about 1 gal. of water per minute through a cooling coil in the oil reservoir of each bearing.

This new design has recently been developed by The Air Preheater Corp., 40 East 34th St., New York.

Long Distance Duplex Thermometer for Oil Switches

LONG-DISTANCE dial type thermometer for use with oil switches has recently been developed, equipped with special internal electric contacts carried by one of the pointers as shown. These contacts are



THERMOMETER MECHANISM, SHOWING TWO POINTERS, TEMPERATURE ELEMENTS AND CONTACTS

so arranged that the contact is closed when the second pointer is 5 deg. F. above the first. A stop arrangement is also provided for closing the contact when the pointer carrying the contact drops to 40 deg. F. In effect, the thermometer is an electrical controller with a variable control point determined by the outside air temperature.

The contact is arranged for use with a lockup type of relay which, in turn, carries the load current of the heater. It was developed by The Foxboro Co., Foxboro, Mass., to meet the particular requirements of a large central station.

The problem was to prevent the condensation of moisture on the inside of oil switches installed at various substations. Oil switches, unlike oil insulated transformers, have no heat generated in them and considerable difficulty is encountered, especially during the winter months, with moisture condensation. This not only lowers the dielectric strength of the insulating oil, but may make the switch inoperative because of the freezing of the water in the switch.

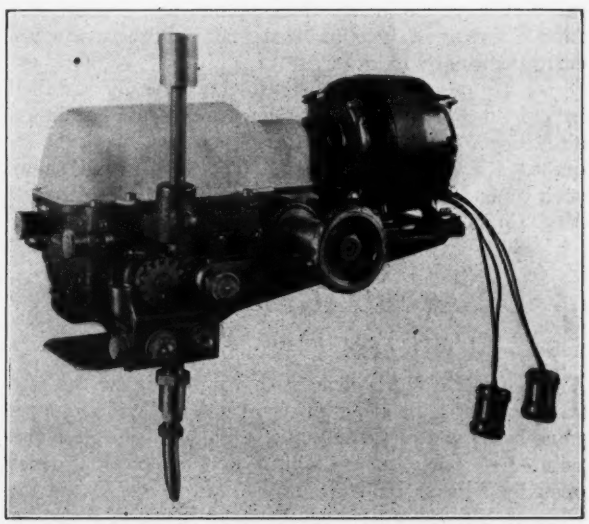
Solution of this problem was obtained by providing a heater in the oil switch and by developing an instrument to turn on the heater should the outside air temperature increase 5 deg. F., above the inside temperature of the switch. Freezing is prevented by having the instrument arranged to turn on the heater in the switch should the temperature drop to 40 deg. F.

Automatic Welding Electrode Feeding Device

IMPROVED FEEDING device on its automatic welding head, to meet advances in the art of automatic welding which call for an increased use of high welding speeds, requiring heavier welding currents and larger sizes of electrode wire than heretofore ordinarily used, is announced by General Electric Co., Schenectady, N. Y. This improvement consists of the addition of geared drive to what was formerly the idler roller in the feeding mechanism. In this way, the large sizes of wire, which are stiff and hard to feed without excessive pressure on the driving rolls, are positively fed without slippage, it is stated, at a regular rate and with only a moderate pressure between the driving rolls.

This device also makes it possible to use curved nozzles to reach into otherwise inaccessible places and to weld in abnormal positions.

For the majority of applications, present practice in automatic welding requires electrode sizes from ⅛-in. to ¼-in. diameter. The improved drive roll gears fur-

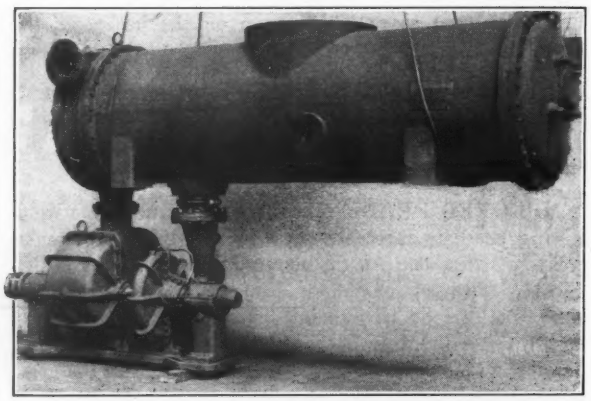


ARC WELDING HEAD WITH AUTOMATIC FEEDING DEVICE

nished on heads for these normal applications will accommodate any size wire from ⅛-in. to ¼-in. diameter without changing gears. Below ⅛ in., the gears are not needed and it is necessary to remove only one gear —that on the drive roll shaft. Sufficient pressure can then be obtained for these small sizes of wire by screwing down the adjustment on the binding roll.

Unit Type Surface Condensers

DECIDED ADVANTAGE to an industrial plant today, in which a power plant designing organization is not maintained, is the simplicity which manufacturers of power plant equipment often incorporate in



UNIT TYPE SURFACE CONDENSER WITH PUMPS ATTACHED

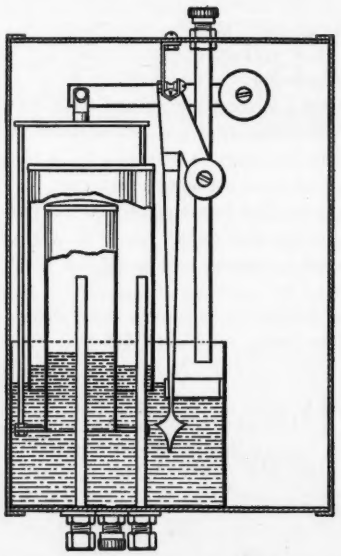
their designs. One such piece of equipment is the unit type surface condenser designed to meet the demand for a simple, compact and highly efficient unit in the smaller sizes of condensers.

Circulating and the condensate pumps are attached underneath, directly to the shell of the condenser. The complete unit is placed beneath the prime mover which it serves; thus a minimum amount of space is required for its installation. By locating the condenser inside the prime mover foundation, the expense for foundation work is minimized and building costs are correspondingly reduced.

Unit type surface condensers can be easily installed in existing plants, because they necessitate minimum alterations. Obviously, little engineering work is required for their installation. The illustration shows such a condenser as made by Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Differential Element for Pointer Draft Gage

DIFFERENTIAL element shown here is for the purpose of indicating pressure differences, minus or plus, between two given points with two bells in a one-pointer element. In the Ellison system, recently developed by Ellison Draft Gage Co., 214 West Kinzie St., Chicago, Ill., a movable bell operates inside of a stationary bell to one side of the fulcrum. The lower absolute pressure communicates with the movable bell from the inside and the higher absolute pressure from the outside. Thus the two pressures acting upon the bell head, the lower absolute pressure below and the higher above the head, will move the bell down and the pointer over the scale in relation to the difference in pressure, it is stated.



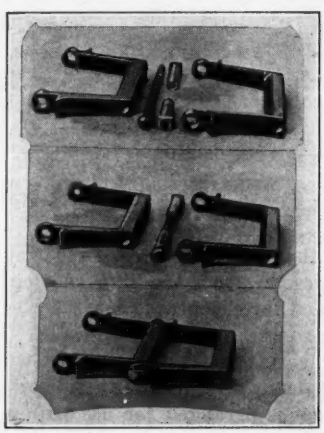
DIAL TYPE MOVEMENT FOR DIFFERENTIAL GAGE

Differential comprises drop between furnace and uptake, across economizers and preheaters, through air filters and all other equipment in which the resistance of air or gas flow is to be measured.

Composite Pintle Conveyor Chain

NEW TYPE of conveyor or drag chain (Brayton Patent) has recently been designed and developed by the American Manganese Steel Co., Chicago Heights, Ill., for use in handling refuse in sawmills, cement clinker and any other material handled by drag chains.

The links are made from manganese steel which in itself is intended to give better wearing qualities and



THREE VIEWS OF PINTLE CONVEYOR CHAIN, SHOWING USE OF STEEL PIN AND MANGANESE STEEL BUSHINGS

longer life. Each link of the new chain is supplied with two hollow manganese steel bushing pins, one for each eye of the link. These are held in place by the steel pin passing through them in the link barrel. This bushing arrangement is intended to enlarge the bearing surface and to do away with bowing and distortion.

Motor Starter for Motors up to 7½ hp.

CONDIT ELECTRICAL MFG. Corp., Boston, Mass., has recently placed on the market a new manually operated air motor starter known as type A-15.

This starter embodies the principle of arc prevention based on contacts of such shape, mass, relation and arrangement with respect to voltage and energy to be

TYPE A-15 MANUAL AIR MOTOR STARTER

absorbed as to reduce the visual evidence of circuit interruption to a spark of negligible importance, even under heavy overloads.

Contacts are assembled in units on insulated carrier bases, one stationary and the other movable. The movable contact base can be withdrawn without the use of tools, permitting ready inspection of both movable and stationary contacts. The stationary and movable contacts are identical and interchangeable.

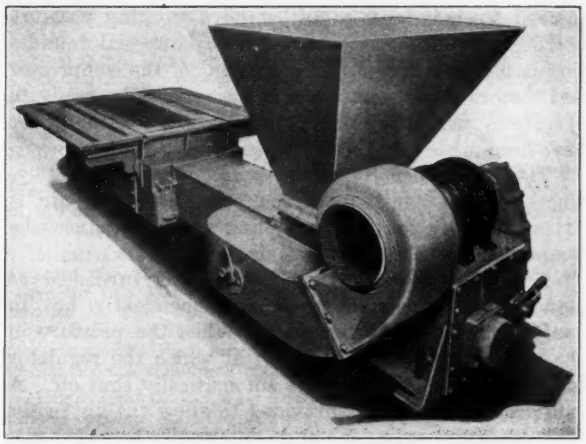
Unusually simple and compact, the starter is enclosed in a substantial steel case arranged with conduit knockouts. Thermal cutouts are provided for time-lag overload protection.

The type A-15 is furnished for 7½ hp. at 550 and 440 v.; 5 hp. at 220 v. and 3 hp. at 110 v.

C-E Fire Tender Stoker

C-E FIRE-TENDER Stoker, shown here, is a junior size underfeed unit designed to be applied to practically any standard make of heating or power boiler in sizes from 100 to 1000 sq. ft. of heating surface. It is made to be readily installed under existing boilers where hand-fired grates are to be replaced by a mechanical stoker. When applied to existing boilers, the original boiler front and firing doors need not be disturbed it is stated; it is only necessary to provide enough clearance space below the existing dead plate to get the lower part of the stoker under.

It is an electrically operated self-contained unit, consisting, in the main, of a large coal hopper, a conveyor screw, a motor drive, a variable speed gear, a forced-draft fan, air-admitting tuyeres and dead plates. Its fuel-feeding capacity is 50 per cent in excess of maximum rated fuel-burning capacity. The stoker body is designed self-supporting, to be entirely independent of furnace brickwork. It is shipped completely assembled ready for installation by its manufacturer, Combustion Engineering Corp., 200 Madison Ave., New York.

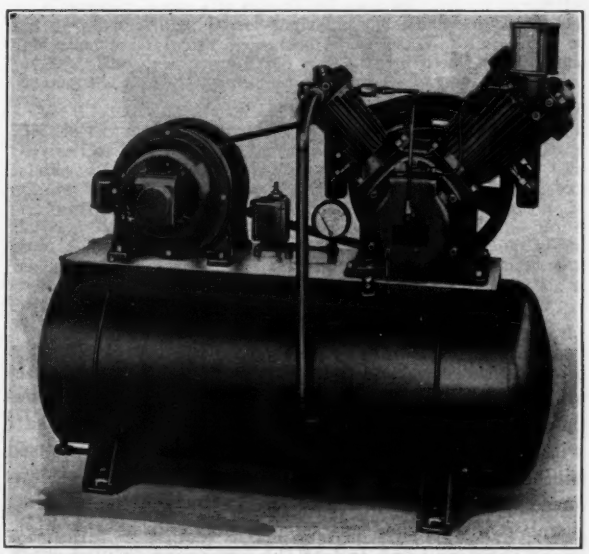


FIRE-TENDER STOKER IS DESIGNED TO BE INDEPENDENT OF FURNACE BRICK-WORK

Type 30 Air-Cooled Two-Stage Compressors

NEW LINE of air-cooled, two-stage air compressors, known as the Type 30, is announced by Ingersoll-Rand Co., 11 Broadway, New York. V-type belt drive is employed. Both motor and compressor have ball bearings.

These units are self-contained, the motor and compressor being mounted on a steel base, which is attached to the top of the air receiver. The latter, of heavy



SELF-CONTAINED TYPE 30 TWO-STAGE AIR COMPRESSOR

pressed steel, is built to withstand a working pressure of 200 lb. With this arrangement, no special foundation is required for correct alignment of the compressor and motor. The compressor is designed to be ready to operate as soon as the electrical connections to the motor have been made and the crankcase filled with oil.

The intercooler is located behind the fan-type flywheel, and a constant current of circulating air is driven directly across the cooling coils to reduce the temperature of the discharge air.

Automatic start and stop control is furnished as standard equipment to operate independently but in conjunction with the unloader. When the pressure in the air receiver reaches a point at which the regulator is set to unload, the motor is automatically shut off. A centrifugal governor is provided to allow the air in the high-pressure cylinder and intercooler to exhaust through the crankcase to prevent the compressor from starting against a load.

Honed cylinders and two oil control rings are used to reduce the oil in discharge air to a minimum. Each piston is run into its respective cylinder to insure a perfect oil seal.

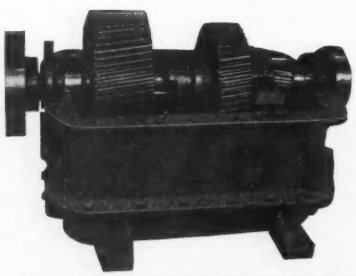
The base of the compressor unit forms a reservoir for the oil, so that no oil pump is required. A bayonet gage is installed to give positive indication of the amount of oil in the reservoir.

A self-cleaning air cleaner is used to keep dirt out of the compressor and requires no attention. The compressor is entirely enclosed. A balanced crankshaft is intended to eliminate destructive vibration.

It is built in four sizes: ¾, 1½, 3 and 5 hp., all for a working pressure up to 200 lb. continuous duty.

Two-Speed Gear Unit for Stoker Drive

PROVISION for operation at two different speeds is made in a Westinghouse-Nuttall double-reduction gear unit for stoker drive, as shown, several of which were recently built for a steam heating plant in Pittsburgh.



TWO-SPEED DOUBLE REDUCTION GEAR FOR STOKER DRIVE

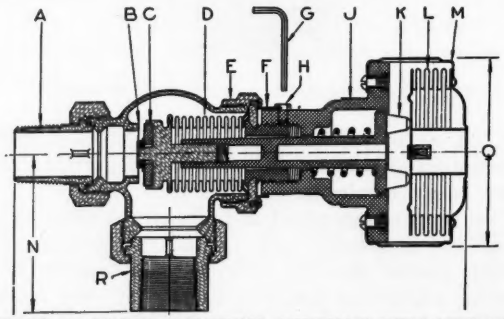
In a three-section case, the high-speed pinion shaft and a splined shaft on which the change gear arrangement is assembled, are alined directly above the shaft with which is the intermediate gear and two slow-speed pinions each having a different number of teeth. Slow-speed pinions are integral with the shaft. A cross member inside the case carries one end of the high-speed shaft and one end of the low speed splined shaft, the other ends of these shafts being supported by the ends of the case. The two gears of different size on the low speed shaft are mounted on roller bearings so that they will turn freely on the shaft when not in use.

Between these two gears, a sliding clutch is manipulated by a lever from the outside of the case. Moving the clutch toward one end or the other of the shaft engages either of the gears, depending upon whether the high or low speed is desired. Timken bearings are used throughout except for the floating gears. Helical gears are used exclusively and are made from forged steel and heat-treated. Gears and bearings are lubricated by a positive splash system, the intermediate gear and a disc at the opposite end of the lower shaft carrying oil from the reservoir in the bottom of the case.

These units have a ratio of 5.88 to 1 in the high speed and 12 to 1 in the low speed, and are used with 12-hp. motors operating at 600-900 r.p.m. for slow-speed service and 1200-1800 r.p.m. in high-speed service. One unit drives four stokers. This gear is a product of Nuttall Division of Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Sylphon Automatic Radiator Valve

COMBINATION PACKLESS radiator valve and temperature control unit, shown herewith and known as the Sylphon Automatic Radiator Valve, was briefly described in our January 1, 1930 issue, in the



SECTION OF VALVE SHOWING SYLPHON BELLOWS USED AS THERMOSTAT AND FOR VALVE STEM PACKING

Power Show report. This valve is designed for use with any two-pipe steam heating system utilizing either floor or ceiling radiators; it is not intended, however, for use where the steam pressure is over 10 lb. per sq. in. or for a hot water heating system. The valve installed in the steam lead right at the radiator, is designed to operate automatically when there is a variation in room temperature and to regulate the flow of steam to the radiator to which it is attached.

Thermostatic element L is a sylphon bellows, made to give enough power to close the valve tightly without undue increase of temperature in the room.

Bakelite parts J join the thermostat to the control valve so that no heat will be conducted to the thermostat. This construction, together with the supporting frame is intended to make the thermostat responsive only to temperature changes of the air in the room.

The valve itself is of rugged design, made of special composition brass. It is of the packless type, a Sylphon bellows D being used instead of packing to eliminate friction and leaks.

Adjustment for different temperatures is obtained by rotating head M, the bakelite portion J being provided with suitable markings and cap nut E carrying a pointer and stop. To maintain the setting, set-screw H is tightened with wrench G.

The Sylphon Automatic Radiator Valve should not be installed in such a way that air will be pocketed around it or cold drafts blow on it but so that the air surrounding the thermostatic element will be at the temperature of the air in other parts of the room at the same level. Under the latter conditions, the valve is designed to maintain uniform temperature at that level.

This device is made by Fulton Sylphon Co., Knoxville, Tenn., in ½, ¾ and 1-in. sizes.

News Notes

TWENTY-FOURTH ANNUAL CONVENTION of the Illuminating Engineering Society is to be held in Richmond, Virginia, from October 7 to 10, 1930, with headquarters at the Hotel John Marshall, according to an announcement recently made public by the Society, 29 West 39th Street, New York City. Present plans contemplate sessions to be devoted to Lighting Practice, Natural Lighting, Lighting Service, Ultraviolet Radiation, Lighting Education, Light in Architecture and Decoration, as well as the usual business sessions on the opening day. The Committee on Lighting Service is also planning to hold another preconvention meeting on the day immediately preceding the opening of the convention, which will be devoted entirely to subjects of particular interest and value to central-station lighting service engineers. This will be held on Monday, October 6, and the convention will open officially on the following day, with adjournment on Friday, October 10. Further data may be obtained from the Illuminating Engineering Society, 27 West 39th St., New York City.

AT THE ANNUAL SHAREHOLDERS' MEETING of The Timken Roller Bearing Co., on April 15, directors elected were H. H. Timken, J. G. Obermier, M. T. Lothrop, J. W. Spray, Henry H. Timken, Jr., of Canton; W. R. Timken of New York and A. C. Ernst of Cleveland. Officers elected at the directors meeting were H. H. Timken, chairman; M. T. Lothrop, president; W. R. Timken, J. G. Obermier, J. W. Spray, H. J. Porter, T. V. Buckwalter, L. M. Klinedinst, vice-presidents; R. C. Brower, secretary-treasurer; J. A. Riley, assistant treasurer; F. F. Tudor, assistant secretary.

WITH SINCERE REGRET, Fairbanks Morse & Company, Chicago, Ill., reports the passing of one of its officials, J. D. Harper, manager of the Diesel Engine division. Mr. Harper died Sunday morning, April 6, of pneumonia. Mr. Harper was born in Indianapolis, June 30, 1861; after his graduation from Rose Polytechnic Institute, he was instructor in engineering there and later at the University of Kansas at Manhattan. He first associated himself with Fairbanks-Morse in 1901 when he became manager of the Diesel Engine division at St. Louis. In 1907, he was made manager of the Dallas sub-branch. In 1908, the Texas Machinery & Supply Co. was organized and he was made president. Ten years later, this subsidiary was discontinued but he remained as manager of the Dallas Branch. Later, in 1920, he was transferred to the home office in Chicago as manager of the Diesel Engine Division.

Of late, he has been closely identified with the activities of the Diesel Engine Manufacturers Association.

CHARLES ALFRED COCKS, who has been associated for 15 yr. with the American Abrasive Metals Co., died on March 26 suddenly, of heart disease. His genial personality has endeared him to the many friends he has made and his loss will be deeply felt by them and by his associates in the organization.

NEW YORK STEAM CORP. has placed a contract with Combustion Engineering Corp. for a new additional steam generating unit to be installed at Kips Bay Station. It is to deliver 750,000 lb. of steam an hour, burning 64,000 lb. of coal an hour and will help to supply steam to five new office buildings from 50 to 80 stories high which are being erected within ½ mile of the plant. The unit will be a double Ladd type boiler with tangentially-fired, pulverized-fuel furnace, having bare tube all metal water-cooled walls and plate type air preheaters.

CHAIN BELT CO. of Milwaukee, Wis., announces the appointment of the Corbin Supply Co. of Macon, Ga., as representative.

B. C. COBB, chairman of the board of The Commonwealth & Southern Corp., announces that the Allied Engineers, Inc., has been organized to take over the assets, business and organizations of Stevens & Wood, Inc., Dixie Construction Co. and Empire Construction Co. The new company will continue in the present location of Stevens & Wood, Inc., 60 John St., until about May 1 when it will move to its new headquarters at 120 Wall St.

E. A. Yates, formerly vice-president of the Southeastern Engineering Co., will be chairman of the board; B. F. Wood, formerly of Stevens & Wood, Inc., will be president; the following will be vice-presidents: W. H. Sawyer, O. G. Thurlow, B. L. Huff, R. W. Stovel, A. C. Polk.

The board of directors will consist of: B. C. Cobb, Thos. W. Martin, Jacob Hekma, T. A. Kenney, E. A. Yates, H. G. Kessler, F. P. Cummings, W. H. Sawyer, O. G. Thurlow, W. H. Barthold, B. F. Wood.

MICHIGAN PUBLIC SERVICE CO., Traverse City, Mich., recently awarded the Electric Machinery Mfg. Co. of Minneapolis an order for two 1375-kv-a. vertical water wheel generators to be installed at their No. 3 Boardman River plant near Traverse City. Driven at 225 r.p.m., the alternators will deliver 2400-v., 60-cycle power. Each generator will have a pilot exciter in order to obtain quick responsive regulation.

INTERNATIONAL RAILWAY FUEL ASSOCIATION, comprising 1700 railway executives, will hold its twenty-second convention at Hotel Sherman, Chicago, May 6 to 9. Reports will be made on Steam Turbine and Diesel Locomotives, on Coal and Oil Firing, on Inspection and Preparation of Coal, on Storage of Coal and Oil, on Coal and Oil-Fired Power Plants. Entertainment will be provided for ladies' afternoons and for all in attendance during the evenings. Arrangements are in charge of C. T. Winkless, secretary-treasurer, Room 700, La Salle St. Station, Chicago.

WARREN C. DRAKE, 5 Beekman St., New York City, is now representing the Boiler Engineering Co., Newark, N. J.

READING CHAIN & BLOCK CORP., Reading, Pa., has appointed R. G. Elliott, 631 Chapel St., New Haven, Conn., to handle its entire line in the state of Connecticut.

GRINDLE FUEL EQUIPMENT CO., subsidiary of Whiting Corp., Harvey, Ill., announces the appointment of R. J. Bender as combustion engineer in charge of development.

LESLIE C. WHITNEY has recently joined the mill organization of the Copperweld Steel Co., Glassport, Pa., as chief metallurgist. Mr. Whitney graduated from Lehigh University in 1922 as metallurgical engineer. For the past five years, he has been employed as assistant head of the Physical Laboratories for one of the largest wire manufacturers in the country.

LESTER E. F. WAHRENBURG, formerly connected with the Byllesby Engineering & Management Corp. as mechanical engineer, has become associated with the Burrell-Mase Engineering Co., Pittsburgh, Pa.

JAMES T. CASTLE, merchant engineer, announces that he has moved his office to 424 First Ave.. Pittsburgh, Pa.

TRI-STATE POWER CO. has acquired the Marion electric power line of which William Holtkamp was president and will take it over within the next two months. The line was built in 1921, extending from West Point to Pilot Grove, Iowa, and St. Paul.

WINTERSET, Iowa, city council has awarded contract to furnish and install a 500-hp. Diesel engine in the municipal power and light plant to McIntosh & Seymour, Auburn, N. Y., at a cost of $44,290. The new power plant is scheduled to be in operation by June 15.

W. J. BERTKE, president of the Sioux City, Iowa, Gas and Electric Co. and head of the newly organized Nebraska Public Service Co., has announced other officers of the new corporation as follows: G. A. Neal and Mark Pendleton, of the Sioux City utilities, vice presidents; Heber Hord, Central City, Nebr., vice president; C. P. Craft, Aurora, Nebr., secretary; William N. Porter, Sioux City, treasurer. Authorized capitalization is $200,000 and the corporation will operate Nebraska holdings of the Sioux City Gas and Electric, have title to such other utilities in that state as may be acquired and represent the Sioux City interests in expansion into other branches of the utility field.

CHAIN BELT CO., Milwaukee, Wis., has recently appointed the R. B. Everett Co. of Houston, Texas, as distributors for its complete line. It has also appointed the J. D. Adams Manufacturing Co., Indianapolis, Ind., as exclusive distributors in the Indianapolis territory.

NEW YORK DISTRICT OFFICES and Eastern Division Offices of Frick Co., Waynesboro, Pa., have been moved from 39 Cortlandt St., where they have been continuously located for more than 30 yr., to the building known as 370 Lexington Ave., New York City, Rooms 612 and 613. J. A. Mikesell, district manager, and his assistants, J. T. Murphy and M. B. Weinberg, comprise the present staff of the district office. L. Howard Jenks, Eastern division manager, is also to be found at the new location.

J. D. Stout has recently been elected vice president of the Terry Steam Turbine Co., Hartford, Conn. Mr. Stout has been associated with the Terry company since 1909 in connection with engineering and sales activities. For several years, he has been manager of the Terry New York Office but from now on he will be located at the home office and works of the company at Hartford, Conn.

National Cork Products, Inc., advises of the removal of its plant to 1579 East Milwaukee Ave., Detroit, Mich.

Transaction of routine business and reëlection of four directors whose terms had ended marked the annual meeting of stockholders of the Westinghouse Electric and Manufacturing Co. held in Pittsburgh, on April 9. The directors, reëlected to four-year terms expiring April, 1934, were: Jerome J. Hanauer, of Kuhn, Loeb & Co., New York; W. L. Mellon, chairman of the Gulf Oil Corp., Pittsburgh; Geo. M. Verity, chairman of the American Rolling Mill Co., Middletown, Ohio, and F. A. Merrick, president of the Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa.

Bailey Meter Co., 1050 Ivanhoe Road, Cleveland, Ohio, announces that it has transferred its office in Chicago, Ill., to 20 North Wacker Drive Building. R. V. Knapp continues as branch manager in this territory.

H. S. Ford, who has been connected with the R. H. Beaumont Co. for the past 15 yr., has become associated with the Bigelow-Liptak Corp. Mr. Ford will be located at the company's headquarters, 5057 Woodward Avenue, Detroit, Mich.

Duquesne Light Co., Pittsburgh, Pa., showed substantial increases in both gross and net earnings during 1929, despite large reductions in wholesale power rates, and the somewhat unsettled business conditions existing at the close of the year, according to the annual report made public today. Gross earnings amounted to $28,568,569, an increase of $1,067,949, while net earnings, before appropriation for retirement (depreciation) reserve were $17,639,734, or $1,385,612 greater than in 1928. The ratio of operating expense, maintenance and taxes to gross earnings established a new low record at 38.25 per cent, as compared with 40.9 per cent for the previous year.

H. M. Byllesby and Co. had a net asset position at the close of 1929 of approximately $40,000,000, it is revealed in the company's annual report just mailed to the stockholders.

Net income from trading and underwriting of securities, interest and dividends, after deduction of all expenses of operation, federal income taxes and preferred dividends, amounted to $4,392,805, equivalent to $6.05 a share on the average amount of common stocks outstanding during the year and $5.36 a share on the common stocks outstanding on December 31. Additional income arising from appreciation in value of marketable securities and common stock investments totalled $12,398,450 after reserves, making total net income of $16,791,255 for 1929.

After deduction of regular dividends and special cash and stock dividends and profit sharing distribution totalling $6,750,275, there remained a surplus of $10,040,980 for the year, which when added to the previous surplus of $9,604,773 made a total surplus of $19,645,753 as of December 31, 1929.

In concluding the report, John J. O'Brien, president, states that the directors feel that notwithstanding the drastic liquidation in securities in the latter part of 1929, the year as reflected by the balance sheet and statement of income shows a marked advance in the company's development and a great strengthening of its financial condition and that it is believed that 1930 will show continued progress.

Gross earnings of the Illinois Power Co. last year exceed by 20.73 per cent the earnings of the preceding year, according to annual report submitted to stockholders at the annual meeting in Springfield, Ill., reaching a total of $2,903,605.88 with net income $681,119.19. After dividends and deductions for depreciation, earnings were $300,189.86, an increase of $114,271.87, 61 per cent in excess of 1928. Sales of electricity, gas and steam for heating were the greatest in history of the company, electrical power consumption being 43,535,263 kw.-hr., an increase of 4,865,504 kw.-hr., or 12.58 per cent over 1928. The report shows that electric sales have increased 200 per cent in the 10-yr. period just ended, with 1929 the banner year of the decade, 7632 hp. in additional business having been secured for industrial activities in the Springfield area. Rural extensions came in for special attention with 83 mi. of pole and wire lines serving 170 sq. mi. additional during the year. Expenditures for additions and improvements were $769,327.16, of which $506,688.88 was expended upon the electric department. Financing for this expansion was through sale of preferred stock, no new bonds being issued, while the bonded indebtedness was actually reduced $75,000. The company's list of stockholders, numbering 3493, is practically all centered in the territory in which the utilities operate.

Citizens of Dow City, Iowa, at a recent special election authorized sale of the municipal electric plant to the Iowa Public Service Co. for $11,500 and granted that company a franchise to operate the utilities in the city.

Fred H. Luecke, for the past few years division manager for the Central Illinois Public Service Co. at Mattoon, Ill., became president of the Missouri Public Service Co. on March 17, with headquarters at Warrensburg, Mo. E. B. Doocy, former division manager at Beardstown, was transferred to the Mattoon office as manager. M. C. Luthringer, manager of the Cipsco ice properties at Springfield succeeds Mr. Doocy and H. C. Stuckenbruck, Springfield, was named successor to Mr. Luthringer.

In order that the supply of power may not be interfered with in case of breakdown at the main steam-driven generating station and also to be in a position to meet readily any sudden increase in demand, two 11,700-hp. Diesel two-stroke engines and generators have recently been installed at the transformer station of the Markische Elektricitatswerke Gesellschaft of Berlin, Germany.

Siemens-Schuckert Co. of Berlin has lately secured a contract from the Krupp Co. for two 16,000-kw turbine generator sets for its ironworks at Rheinhausen, Germany. The turbines are of the condensing type and are intended to work with steam at a pressure of about 400-lb. per sq. in. and at a temperature of 750 deg. F.

Installation of additional generating capacity is planned for the Fargo and Minot, North Dakota, steam plants of Northern States Power Co., according to Halford Erickson, vice president in charge of operation, Byllesby Engineering and Management Corp.

At Fargo, an extension will be built onto the present electrical gallery of the plant, this extension to be a one story and basement building, of the same height as the present building. A 3000-kw. turbine generator will be installed in a vacant space alongside the present units in the plant.

One 2500-kw. turbine-generator will be installed in the Minot plant, and one 6000-sq. ft. boiler will be moved from the Riverside Station of the company to the Minot plant.

Books and Catalogs

Steam Tables and Mollier Diagram. By Joseph H. Keenan. Published by the American Society of Mechanical Engineers, 29 W. 39th St., New York, N. Y. 7½ by 10 in.; cloth, 63 pages.

Meeting a long felt need of the power industry, these new tables, extending to 3500 lb. per sq. in. pressure and 1000 deg. F. total temperature, should find a place in every engineer's library.

Symbols used are taken from the latest test prepared by the A. S. A. subcommittee on symbols for heat and thermodynamics. The tables themselves, based on the new international calorie, are developed from the latest experimental data of the investigators in this country and in Europe.

Six tables and a large copy of the latest Mollier diagram are included. Among these tables are: saturated steam temperature table in degrees from 32 to 706 deg. F.; saturated steam pressure tables in pounds from 0.20 to 3226 lb. abs. pressure and a superheated steam table from 1 to 3500 lb. abs. pressure and from 102 to 1000 deg. F. Superheated steam tables are all expressed as total temperatures, and degree of superheat is not used, an interesting change from the old familiar tables in general use. Conversion tables from f.p.s. to the c.g.s. system and logarithms to the base 10 and base *e* are also included.

Mechanical Engineering Laboratory Practice. By Charles F. Shoop and George L. Tuve. Published by The McGraw-Hill Book Co., 370 Seventh Ave., New York, N. Y.; 6 by 9 in., cloth binding; first edition, 478 pages; price, $4.00.

Although intended primarily as a text book for laboratory work in engineering schools, the arrangement of the text is such that it forms a valuable reference book for engineers. The foundation of the book is correct testing methods but the accompany text is in effect a summary of the present knowledge of the subject under discussion. References at the end of each chapter are valuable for those interested in going deeper into the subject, while the material given in the book is sufficiently complete to answer the needs of the average engineer without causing confusion. Following chapters on report writing, instruments and general procedure, there are chapters on lubricants, heat transfer, gases, fluid flow pumps and compressors, steam prime movers, automatic regulation, refrigeration, internal combustion engines and a 30-page appendix of tables, constants and general technical information.

Steam, Air and Gas Power. By William H. Severns and Howard E. Degler. John Wiley & Sons, Inc., 440 4th Ave., N. Y.; 6 by 9 in., cloth, 425 pages; price, $4.00.

Prepared as an elementary text for classes at the University of Illinois, this book covers the application of thermodynamic prin-

ciples to steam, fuels, boilers, heat power plants, engines, turbines, steam auxiliaries, compressed air machinery and internal combustion engines. To follow the mathematical discussions, knowledge of algebraic equations and calculus is needed but descriptions of heat generating and utilizing equipment are independent of such discussion, are clear and fully illustrated and form a good introduction to the field of power engineering.

In this respect, the authors have covered exceptionally well all the heat equipment of the power plant so that the reader will get a good group of the fundamentals of modern practice and equipment. Problems are given to illustrate the application of equations and laws derived in the text. Also sufficient tables of data are included to make the study of text and working of problems possible without reference to outside sources.

The book forms a satisfactory step from the study of mathematics and the sciences to their application in heat machinery.

WELDING ENCYCLOPEDIA, Seventh Edition, compiled and edited by L. B. Mackenzie and H. S. Card, 540 pages; 670 illustrations; flexible binding; published by The Welding Engineer Publishing Co., 608 S. Dearborn St., Chicago, Ill.; price, $5.

Two hundred pages of definitions and discussions of words and terms used in welding literature are followed by treatment of gas, arc, resistance and thermit welding, with instructions for all commercial metals by each of these processes. Separate chapters are devoted to pipe, tanks, boilers and structural steel. Cutting and the training of operators are also given separate treatment. Additions have been made to include information on newer applications of welding, such as aircraft, machine parts, structural steel, special alloy steels and nonferrous metals and their alloys.

WESTINGHOUSE ELECTRIC AND MFG. CO., in its new publication, "Lightning Investigation, Discoveries, and Control," presents an account of the lightning investigations made by Westinghouse engineers during 1929, conclusions derived from this research, and descriptions of the construction and the application of autovalve lightning arresters. The nature and magnitude of transient voltages on electrical systems is discussed with respect to the recent investigations and photographs of lightning surges recorded by the cathode ray oscillograph are included in this 20-page publication. The autovalve arrester, the operation of which is somewhat similar to a safety valve which discharges under pressure and shuts off when the pressure drops, is described with reference to the principle of operation, the construction, and the installation. Charts are used to show characteristics of surges, glow and arc discharges, breakdown voltages of small gaps in air, the performance of arresters, and transformer sizes for economic balance of arrester cost and benefit.

This publication is identified as Circular 1737-E and is obtainable upon request.

SUCCESSFUL Canadian Pumping Stations are illustrated and described and their locations shown in a 28-page booklet issued by the De Laval Steam Turbine Co., Trenton, N. J. The stations covered use motor-driven, gasoline-engine-driven and geared, steam-turbine-driven pumps. In most cases the sizes and records of performance are also stated.

NICKEL-CHROMIUM steel valves and bolts for high temperature service is the title of bulletin No. 15 on Nickel Steel Applications issued by The International Nickel Co., Inc., 67 Wall St., New York, N. Y. Results of tests and the effects of creep stress are discussed and standard specifications given for high-temperature bolting material of various grades.

WESTINGHOUSE ELECTRIC & MFG. CO. announces a new line of high voltage oil circuit-breakers, type G0, some of them equipped with "De-ion Grids" and conforming to the new N. E. L. A. voltage ratings. The "De-ion Grids," as described in the March 1 and March 15 issues of Power Plant Engineering, reduce the arcing time and the arc energy dissipated in the breaker structure. The arc interruption takes place in arc extinguishing devices supported from the terminals.

Circulars 1872 and 1875 describe the construction, operation and application of the various models of the G0 line. Circular 1872 deals with high voltage oil breakers, rated at 115,000 to 230,000 v.; and Circular 1875 describes breakers rated at 46,000, 69,000, and 92,000 v. These publications can be obtained from the Westinghouse Electric and Mfg. Co. upon request.

NEW PRINCIPLE in Burner Design is illustrated and described in a bulletin issued by Ashmead-Danks Co., 7016 Euclid Ave., Cleveland, Ohio, giving details of an adjustable orifice burner for gas or powdered fuel.

ENTITLED, WESTINGHOUSE Safety Switches and numbered 226, a new catalog recently published by the Westinghouse Electric and Manufacturing Co., contains a complete line of porcelain base safety switches, industrial safety switches, motor starting switches, range and commercial cooking switches, meter service switches and breakers, and overload protective devices. Every detail for service and longevity is the controlling factor of design. The new development, the Deion arc quencher is employed on the 575-600 switches.

Type "C" WK-97 switches are introduced in this publication. These switches are very sturdy and represent features of service that make them desirable for motor circuits. They are single throw, "quick make" and "quick break" with Deion arc quenchers on 575-600 v. sizes. Also, a new three-pole breaker has been added to the WK-50 line of meter service breakers. This breaker is designed to eliminate fuses, answering all requirements for sealed main fuses, accessible fuses, interlocking doors and many other features of meter service switches. It may be operated manually as a switch and has a "quick make and break" action. The Deion feature is also incorporated in this breaker.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC.

required by the Act of Congress of August 24, 1912, of Power Plant Engineering, published semi-monthly at Chicago, Ill., for April, 1930.

State of Illinois, } ss.
County of Cook, }

Before me, a Notary in and for the State and county aforesaid, personally appeared Charles S. Clarke, who, having been duly sworn according to law, deposes and says that he is the Secretary of the Power Plant Engineering and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 411, Postal Laws and Regulations, printed on the reverse of this form, to-wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Publisher, Technical Publishing Co., Chicago, Ill.
Editor, Arthur L. Rice, Chicago, Ill.
Managing Editor, R. E. Turner, Chicago, Ill.
Business Manager, E. R. Shaw, Chicago, Ill.

2. That the owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address, as well as those of each individual member, must be given.)

Technical Publishing Co., Chicago, Ill.
E. R. Shaw, Chicago, Ill.
Arthur L. Rice, Chicago, Ill.
K. L. Rice, Chicago, Ill.
Charles S. Clarke, Chicago, Ill.
R. E. Turner, Chicago, Ill.
A. W. Kramer, Chicago, Ill.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.)

There are none.

4. That the two paragraphs next above giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustees or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

CHAS. SANFORD CLARKE, Secy.

Sworn to and subscribed before me this 29th day of March, 1930.

[Seal.] EDDIE H. KAHL,
Notary Public.

(My commission expires March 20, 1932.)

Power Plant Construction News

Ala., Fairfield—The Tennessee Coal, Iron & Railroad Co., Birmingham, plans installation of electric power equipment in connection with an expansion and improvement program at local steel mill, including installation of new rolling mill, and other units, entire project to be completed in about 12 months at cost of more than $6,000,000. Company is a subsidiary of the United States Steel Corporation, 71 Broadway, New York.

Ariz., Dripping Springs—The United Vanadium Corporation, Washington Building, Los Angeles, Calif., plans installation of electric power equipment, tramway system, ore bins and other mechanical equipment, in a proposed new milling plant at Dripping Springs, entire project reported to cost more than $150,000.

Calif., Stockton—The Holly Sugar Corporation, Colorado Springs, Colo., plans installation of electric power equipment in proposed beet sugar mill unit at Stockton, entire project to cost more than $500,000. Work is scheduled to begin late in the summer, and it is understood will be carried out as a development of the Franklin Sugar Co., Preston, Idaho, an affiliated organization.

Calif., Trona—The American Potash & Chemical Corporation, Woolworth Building, New York, plans construction of a steam-operated electric power plant, in connection with an expansion program at potash and borax properties at Trona, entire project to cost more than $2,500,000. United Engineers & Constructors, Inc., 112 North Broad Street, Philadelphia, is engineer.

Fla., Panama City—The Southern Kraft Corporation, operated by the International Paper Co., 100 East Forty-second Street, New York, plans construction of a steam power plant at proposed new kraft paper mill on tract of land acquired at Panama City. Plant machinery will be electrically operated, entire project to cost over $5,000,000.

Ill., Chicago—The Commonwealth Edison Co., 72 West Adams Street, has begun the construction of an equipment storage, distributing and service plant addition at Twenty-second and Throop Streets, two and three-story, 100 x 240 ft., and 240 x 260 ft., estimated to cost close to $1,000,000, with equipment. Nimmons, Carr & Wright, 333 North Michigan Avenue, Chicago, are architects.

Ind., Fort Wayne—The Wayne Knitting Mills, Inc., is completing plans for a one-story boiler plant for service at mill, to be 65 x 108 ft., reported to cost close to $200,000, with equipment. Three boiler units with auxiliaries will be installed. R. I. Spaw is plant engineer.

Iowa, Missouri Valley—The Central States Electric Co., Cedar Rapids, Iowa, has secured a franchise at Missouri Valley and vicinity, and is said to be planning the installation of a gas generating plant and system. Estimates of cost are being made.

Kan., Garden City—Swift & Co., Kansas City, Mo., meat packers, will install a refrigerating plant in proposed new packing house at Garden City, entire project reported to cost $150,000. Headquarters are at the Union Stock Yards, Chicago, Ill.

Mass., Arlington—The Metropolitan Ice Co., Arlington, plans rebuilding of portion of plant, recently destroyed by fire with loss reported in excess of $80,000.

Mass., Waltham—The Middlesex County Hospital District, Boston, care of James H. Richie & Associates, 100 Arlington Street, Boston, architects, has approved plans for the construction of a steam power plant in connection with a new hospital group on the Trapelo Road, Lexington-Waltham, including mechanical laundry, etc., entire project to cost $1,500,000. Work will be placed under way at once.

Mich., Grand Rapids—The Consumers Power Co., Jackson, is arranging an expansion and betterment program at Grand Rapids and vicinity, changing service from 30 to 60 cycles, with installation of equipment for increased operations, to cost more than $3,000,000. Stevens & Wood, 60 John Street, New York, are consulting engineers.

Mo., St. Louis—F. M. Stambaugh & Sons, Inc., 4356-58 Maffit Avenue, plans installation of electric power equipment in connection with addition to tool-manufacturing plant, entire project reported to cost close to $100,000. Julius Taring, 2806 North Grand Boulevard, is architect.

N. C., Burlington—The Perfection Hosiery Mills, Inc., Main Street, plans installation of electric power equipment, in connection with proposed rebuilding of portion of plant, recently destroyed by fire with loss reported at about $100,000, including machinery.

N. D., Langdon—The Otter Tail Power Co., Fergus Falls, Minn., is reported planning a new steam-operated electric power plant at Langdon to cost about $120,000, with equipment.

Nev., Fallon—The City Council is reported considering a municipal electric light and power plant to cost close to $100,000, with equipment. The Nevada Valley Power Co., is now furnishing local service.

N. J., Jersey City—The Pennsylvania Railroad Co., Pennsylvania Terminal, New York, will install elevating, conveying and other mechanical handling equipment with electric power facilities on proposed new steel pier, 905 ft. long on the Hudson River, Jersey City, to cost about $2,000,000. Plans have been filed.

N. J., New Brunswick—The City Council is having plans completed for a new pumping station at Weston Mills, for municipal water service, estimated to cost about $60,000. Asher Atkinson, City Hall, is engineer.

N. Y., Glens Falls—The New York Power & Light Corporation, Albany, plans rebuilding of portion of power plant at Glens Falls, destroyed by fire April 9, with loss reported at close to $35,000, including equipment.

Ohio, Cleveland—The American Steel & Wire Co., Cleveland, plans installation of electric power equipment in connection with an expansion and betterment program at its local Cuyahoga Works, entire project estimated cost over $1,000,000.

Ohio, Middletown—The Crystal Tissue Co., plans installation of electric power equipment in connection with proposed addition to mill to cost about $100,000. Schenck & Williams, Third National Bank Building, Dayton, Ohio, are architects and engineers.

Ohio, Toledo—The Prest-O-Lite Co., Inc., 30 East Forty-second Street, New York, as subsidiary of the Union Carbide & Carbon Corporation, same address, plans installation of electric power equipment in proposed new plant at Toledo, entire project to cost about $200,000.

Okla., Altus—The Municipal Water & Light Department is said to be planning immediate rebuilding of municipal electric light and power plant, destroyed by fire April 8, with loss reported in excess of $225,000.

Pa., Philadelphia—The West Philadelphia Stock Yards Co., Thirtieth Street, near Race Street, plans installation of electric power equipment, refrigerating machinery, etc., in proposed six-story meat packing plant on Grays Ferry Avenue, entire project to cost more than $800,000. C. B. Comstock, 122 East Forty-second Street, New York, is architect and engineer.

Texas, Big Lake—The Texon Oil & Gas Co., operated by the Texon Oil & Land Co., Big Lake, contemplates the construction of a carbon black plant in Reagan County, including installation of battery of air compressors and other power equipment, entire project reported to cost more than $100,000. Application for permission has been made to the State Railroad Commission.

Texas, Woodsboro—The Central Power & Light Co., Frost National Bank Building, San Antonio, has approved final plans for a one-story ice-manufacturing plant at Woodsboro, reported to cost about $60,000, with equipment. John M. Marriott, address noted, is company engineer.

Wis., Manitowoc—The Wisconsin Fuel & Light Co., Chicago Street, is reported planning a new coal-gas generating station on local site. Estimates of cost will soon be made. Thomas Danhy is manager.

Wis., Milwaukee—The Chicago & Northwestern Railroad Co., 400 West Madison Street, Chicago, plans installation of electric power equipment in proposed addition to grain elevator on Kinnickinnic Avenue, Milwaukee, estimated to cost about $500,000. The J. S. Metcalf Co., 111 West Jackson Boulevard, Chicago, is engineer.